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FOREWORD

THE PEAT FORUM AND THE PEAT FOR ENERGY AND CHEMICALS R & D PROGRAM

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Peat Program Manager
Division of Energy Research and Development
National Research Council of Canada

Ralph Overend sends his apologies for being unable to participate in the Workshop today. He sends his best wishes for fruitful deliveration.

Let me first speak of the National Research Council's Peat for Energy and Chemicals Program as I am now the Manager. This Program was founded under the umbrella of the National Energy Program and currently addresses the following medium and long term objectives:

(1) develop a first level inventory that will enable evaluation of the peat resources in the context of land use competition and environmental considerations;

(2) develop low cost inventory technology;

(3) develop year round peat wet mining and dewatering technologies appropriate to Canadian conditions;

(4) develop peat processing technologies for the manufacture of fuel and chemical commodities;

(5) assess and evaluate the environmental impacts of large scale peat utilization.

The National Research Council is charged with the coordination and implementation of the necessary R & D to achieve the above objectives.

In general, the Program is referred to as the Peat for Fuels and Chemicals Program and this will certainly be the emphasis of the Program. We are convinced that any in-depth considerations for utilization of Canada's peat resources for these purposes must be preceded by a first level assessment of the resources. Thus the Program will, within budgetary constraints, encourage and stimulate methods of research for assessments carried out by the resource holders, normally the provinces. It will endeavour through having access to the data from those and inventories conducted for other land use considerations, such as forestry and agriculture, derive that first level estimate of peat fuel resources.

AVANT-PROPOS

LE FORUM SUR LA TOURBE ET LE PROGRAMME DE R & D SUR LA TRANSFORMATION DE LA TOURBE EN ÉNERGIE ET EN PRODUITS CHIMIQUES

T.E. Tibbetts
Chef du programme de la tourbe
Division de la recherche et du développement énergétiques
Conseil national de recherches du Canada

Ralph Overend s'excuse de ne pas pouvoir participer à l'atelier d'aujourd'hui. Il nous transmet ses meilleurs voeux pour que notre rencontre soit profitable.

Permettez-moi d'abord de vous parler du Programme de R & D sur la transformation de la tourbe en énergie et en produits chimiques que je dirige au Conseil national de recherches. Il a été établi dans le cadre du Programme énergétique national et comporte les objectifs à moyen et à long termes suivants:

(1) dresser un premier inventaire qui nous permettra d'évaluer les ressources en tourbe en tenant compte des autres utilisations possibles des terres et des facteurs écologiques;

(2) metre au point des méthodes peu coûteuses d'inventaire;

(3) mettre au point des techniques d'extraction humide et d'essorage de la tourbe, adaptées aux conditions propres au Canada et pendant toute l'année;

(4) mettre au point des techniques de traitement de la tourbe en vue de la fabrication de produits combustibles et chimiques.

(5) évaluer les répercussions sur l'environnement de l'utilisation en grand de la tourbe.

Le CNR est chargé de diriger le Programme et de coordonner et de mettre en application la R & D nécessaire pour atteindre ces objectifs.

Le Programme est ordinairement appelé "programme de transformation de la tourbe en combustibles et en produits chimiques" et c'est certainement vers cela qu'il sera avant tout orienté. Nous sommes convaincus que tout projet d'envergure visant ces utilisations devra attendre une première évaluation des

The Program has demonstrated interest in the technology of inventory acquisition through a project contracted to Remotec on impulse radar profiling of peat deposits; promotion of the Peat Inventory Methodology Workshop; and, planned funding in the next and ensuing fiscal years of critical assessments and demonstrations of inventory methodology.

The Program does not offer support to technologies that are close to economic application as a wide variety of assistance in the form of demonstration funds is already available for such projects.

Research under the program will proceed both in-house and by contract. A number of activities are being considered or are underway with Environment Canada's EPS and CFS; Agriculture Canada's LRRI; and contracted assessments of wet mining and dewatering technologies.

We turn now to the Peat Forum and the Peat Inventory Methodology Workshop. Ralph Overend was responsible for the establishment of the Peat Forum (a nucleus of peat expertise residing in several federal agencies active in Peat R & D) to advise on and facilitate coordination of NRC's Peat for Energy and Chemicals Program. It is intended that where appropriate, the individual agencies making up the Forum will lead the federal efforts in their respective specialization. Because of the nature of peat and its overlapping jurisdiction, not all of the current federal peat activity is represented in the Peat Forum; however, liaison is maintained with the Secretariats of such bodies as the Peatlands Subcommittee of the NRC Associate Committee on Geotechnical Research and the Natural Wetlands Working Group of the Lands Directorate chaired by Charles Tarnocai of LRRI.

One of the first activities of the Peat Forum was the publication of a Directory of peat research in Canada over the last 10 years. It is intended that this Directory will be periodically revised to reflect the continuing research on peat and peatlands.

This Peat Inventory Methodology Workshop is happening as a result of discussions within the Peat Forum whose members saw a great need to clarify and bring into focus the activities across Canada associated with peat and peatland resource assessments. It is hoped that the deliberations of this Workshop will establish some clear directions for the methodology of peat inventory and that eventually standard procedures and tests will evolve to allow accurate national assessments of the peat resources. We do not expect all problems to be solved during these two days,

ressources. Ainsi, le Programme encouragera et stimulera, dans les limites financières permises, la recherche de méthodes d'évaluation qui sera effectuée par ceux qui possèdent les ressources, généralement les provinces, et tâchera, après avoir eu accès à leurs données et à celles des inventaires entrepris en vue d'autres utilisations des terres, comme la foresterie et l'agriculture, de produire cette première évaluation des ressources en tourbe utilisable à des fins énergétiques.

Le Programme a fait preuve d'intérêt pour les techniques d'inventaire par un projet, donné à contrat à Remotec, pour déterminer le profil des tourbières au moyen de radar à impulsions; par la promotion de l'atelier sur les méthodes d'inventaire de la tourbe; et par le financement prévu, pour les prochaines années financières, de l'évaluation et de la démonstration des métnodes d'inventaire.

Le Programme n'affrira pas d'aide pour le transfert de technologies connues et qui sont sur le point d'etre rentables car une gamme de programmes d'aide est déjà disposible pour de telles activités, sous forme de funds de démonstration.

La recherche dans le cadre de ce programme se fera à la fois par les services fédéraux et par contrat. Un certain nombre d'activités sont déjà en cours d'étude ou de réalisation, notamment par le SPE et le SCF d'Environnement Canada et par l'IRT d'Agriculture Canada. On procède également, à contrat, à l'évaluation des méthodes d'extraction humide et d'essorage de la tourbe.

Maintenant, pour ce qui est du Forum sur la tourbe et de l'atelier sur les méthodes d'inventaire de la tourbe. Ralph Overend était chargé de l'établissement du Forum (un noyau de compétences et de connaissances concernant la tourbe que possèdent plusieurs organismes fédéraux qui s'intéressent activement à la R & D sur la tourbe) en vue d'offrir des conseils relativement au programme du CNR de transformation de la tourbe en énergie et en produits chimiques, et d'en faciliter la coordination. On voudrait bien que, le cas échéant, les organismes membres du Forum se chargent de concrétiser les efforts fédéraux dans leur spécialité respective. Vu la nature de la tourbe et du chevauchement des compétences en ce qui la concerne, les activités fédérales actuelles dans ce domaine ne sont pas toutes représentées au Forum; cependant, on conserve des rapports avec les secrétariats d'organismes comme le sous-comité de la tourbière, du Comité associé de recherches en géotechniques du CNR, et le Groupe de travail sur les terres humides naturelles, de la

however it is expected that we will all be more aware of the tools available for peat resource assessments and the various methods being followed. We will hope that future workshops will demonstrate that through cooperation and standardization we are closer to speaking the same language when assessing our peat resources.

In this regard I suggest to the Workshop that one task could be to place our first level resource assessments on a basis similar to mineral resource assessments by defining our resources in various categories corresponding to the level of confidence that we have in their existence. An example could be the following definitions:

(1) Inferred resources - volume estimates based solely on Telesat data, aerial photographs, topographical maps and based primarily on assumed depth of not more than one metre.

(2) Indicated resources - volume estimated by use of Telesat data, aerial reconnaissance, radar, aerial photographs, topographical maps, and at least one measured depth extrapolated over entire area.

(3) Measured resources - Volume and quality measured and evaluated over the entire deposit by generally recognized sampling and analytical techniques, e.g. the New Brunswick inventory.

(4) Reserves - measured resources that can be economically exploited - presently, this would pertain only to those peatlands now being used for peat moss production, forestry and agriculture.

Such a system I believe would place the data derived in better perspective and would permit greater flexibility. Movement of data from one category to the other as the level of confidence increased would be simple and acceptable if we clearly define the categories. We should all strive to strike the term "reserve" from our vocabulary when quantifying and qualifying our peat reserves until the deposits can be economically assessed.

Direction générale des terres, qui est dirigé par Charles Tarnocai, de l'IRT.

Une des premières activités du Forum sur la tourbe a été de publier, au cours des 10 dernières années, le Répertoire canadien de la recherche sur la tourbe. Il est prévu de la réviser périodiquement afin de tenir compte de la recherche poursuivie sur la tourbe et les tourbières.

Le présent atelier est le résultat de discussions au sein du Forum dont les membres ont ressenti un grand besoin de clarifier et de mettre en perspective les activités canadiennes portant sur l'évaluation des ressources en tourbe et en tourbières. Nous espérons que ses délibérations pourront orienter clairement les méthodes d'inventaire de la tourbe et que, par la suite, il en découlera des méthodes et des essais normalisés d'évaluation de cette ressource à l'échelle du pays. Nous ne nous attendons pas que tous les problèmes soient réglés au cours de ces deux journées; toutefois, nous prévoyons que nous seront tous plus conscients des outils disponibles pour effectuer ces évaluations ainsi que des diverses méthodes utilisées actuellement. Il est à souhaiter que les ateliers tenus à l'avenir pourront montrer qu'avec la collaboration et la normalisation on pourra "parler le même langage" en évaluant nos ressources en tourbe.

Dans ce contexte, je vous propose qu'une de nos tâches soit de placer notre première évaluation des ressources à un niveau semblable à celui des évaluations des ressources minérales, c'est-à-dire, définir ces ressources selon différentes catégories qui correspondent au degré de confiance que nous accordons à leur existence. Voici quelques définitions, à titre d'exemples:

(1) ressources présumées - estimations volumétriques fondées uniquement sur les données Telesat, les photographies aériennes et les cartes topographiques, et sur une profondeur supposée égale, au plus, à un mètre;

(2) ressources extrapolées - estimations volumétriques fondées sur les données Telesat, la reconnaissance aérienne, le radar, les photographies aériennes et les cartes topographiques, et sur au moins une profondeur mesurée, extrapolée à l'ensemble de la superficie étudiée;

(3) ressources mesurées - volume et qualité mesurés et évalués par rapport à l'ensemble d'une tourbière au moyen de méthodes d'échantillonnage et d'analyse généralement reconnues (ex. l'inventaire du Nouveau-Brunswick);

(4) réserves - ressources mesurées qui peuvent être exploitées économiquement. Actuellement, cela s'appliquerait seulement aux tourbières servant maintenant à la production de sphaigne, à la foresterie et à l'agriculture.

Un système de ce genre pourrait, à mon avis, mieux situer les chiffres obtenus et procurerait plus de souplesse. Le passage d'une catégorie à l'autre, à mesure que le seuil de confiance augmente, serait chose simple et acceptable, à condition de définir clairement chaque catégorie. Nous devrions tous nous efforcer de rayer le terme "réserve" de notre vocabulaire en ce qui concerne le volume ou la qualité de la tourbe jusqu'à ce qu'on puisse soumettre les tourbières à une évaluation éeonomique.

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INTRODUCTORY REMARKS FOR PEAT FORUM WORKSHOP

As Director of the Land Resource Research Institute, I am pleased to have this opportunity to welcome all of you to this Workshop on Peat for Energy in Canada. I am sure all of us realize the importance of peat as a natural resource. Furthermore, we are all aware as well of the possible conflicts relating to the use of peat for energy purposes and the possible environmental consequences. Therefore, because of the importance of peat from the point of view of wildlife, controlling the flow of water through the various seasons and its direct potential for producing food and fibre, decisions regarding the utilization of the peat resources of Canada must be made carefully.

With the broad experience and expertise of the group that is meeting here I have no doubt that any recommendations for the allocation and use of peat resources for energy needs in Canada will be made thoughtfully and wisely.

Again, I would like to take this opportunity to welcome all members of the Workshop to the Land Resource Research Institute and to invite you to visit the staff of the Institute and the facilities that we have here when you have the opportunity.

J.S. Clark
Director
Land Resource Research Institute

REMARQUES LIMINAIRES POUR L'ATELIER DU FORUM SUR LA TOURBE

En tant que directeur de l'Institut de recherche sur les terres (IRT), j'ai le plaisir de vous souhaiter la bienvenue à cet atelier sur l'utilisation de la tourbe à des fins énergétiques au Canada. Je suis certain que nous sommes tous conscients de l'importance de la tourbe comme ressource naturelle. De plus, nous connaissons tous les conflits liés à cette utilisation de la tourbe et leurs conséquences possibles sur l'environnement. C'est pourquoi, compte tenu de l'importance de la tourbe pour la faune les débits de l'eau d'une saison à l'autre, et de son potentiel direct pour la production de nourriture et de fibres ligneuses, on devra prendre les précautions nécessaires lorsqu'on voudra exploiter cette ressource nationale.

Vu le vaste éventail d'expériences et de connaissances des gens ici réunis, je suis sûr que toute recommandation relative à l'affectation et à l'utilisation de la tourbe à des fins énergétiques au Canada sera faite de façon réfléchie et sage.

Encore une fois, je tiens à vous souhaiter la bienvenue à l'IRT et je vous invite à rencontrer son personnel et à visiter ses installations lorsque vous en aurez l'occasion.

J.S. Clark
Directeur
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PEATLAND ECOLOGY STUDIES IN THE BOREAL WETLAND REGION[1]

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ABSTRACT

Studies of the dynamics of peatlands were undertaken in the Prairie Provinces to serve as background information for reconnaissance surveys. During such multidisciplinary studies different wetland types are identified, and the vegetation and peat sections are described and sampled. Chemical and physical properties of the peat are determined. Preliminary results of the first year of studies show that in central Alberta the long-term average rate of peat accumulation is about 0.55 mm/yr, with a dry matter peat increment of 50-60 g/m^2/yr. Vegetation communities identified from peat macrofossils are similar to those presently occurring in the area.

RÉSUMÉ

Des études sur la dynamique des tourbières ont été entreprises dans les provinces des Prairies, pour réunir l'information de base nécessaire pour les travaux de prospection de reconnaissance. Au cours de ces études pluridisciplinaires, les différents types de terres humides sont identifiés et leur végétation ainsi que des sections de tourbe sont échantillonnées et décrites. Les résultats préliminaires de la première année d'étude montrent que dans le centre de l'Alberta, le taux d'accumulation moyen à long terme de la tourbe est d'environ de 0,55 mm/an, correspondant à 50-60 grammes de matière sèche par mètre carré par an. Les communautés végétales reconstituées à partir des macrofossiles retrouvés dans la tourbe, sont semblables à la végétation observée actuellement dans la région.

INTRODUCTION

Peatlands are widespread in the Boreal Wetland Region, even in the Prairie Provinces. Current estimates indicate that about 160 000 km^2 of Alberta, 60 000 km^2 of Saskatchewan, and 200 000 km^2 of Manitoba are covered by peatlands, mostly north of the Prairie zone. Yet, in spite of the large areas involved, very little information is available on the extent of the peatlands, amounts of peat involved and their physical, chemical or botanical characteristics. Although excellent studies were made of a few individual wetlands (cf. Vitt *et al.* 1975, Slack *et al.* 1980, Jeglum 1973a, 1973b, Bannatyne 1980), these were largely single discipline oriented and therefore lack data essential for a more comprehensive regional study.

In 1981 the Canadian Forestry Service initiated a study of wetland dynamics in the Boreal Wetland Region of the Prairie Provinces. In this study, wetland vegetation, both past and present, is examined in relation to environmental conditions. This allows a correlation of the surface features (vegetation, morphology, hydrology) to the quantity and quality of peat. This information will form the basis of a broad-level reconnaissance survey for estimating the extent, quantity and quality of peat, utilizing aerial photo or other remote sensing information.

In this paper the methodology of data aquisition is described and preliminary results of investigations in Alberta during 1981 are outlined.

METHODOLOGY

Field Studies

1. *Site Selection* - Initially, peatlands are identified on aerial photographs and those that show a satisfactory development of surface features and are free of disturbance, are

[1]This study is partially financed through the Peat Forum.

selected for study. Care is taken to include a wide spectrum of wetland types in this study.

At each site the sampling points are selected on the basis of changes in vegetation or in the morphology of the wetland. Different components of a pattern are sampled to ascertain the permanence or changes in the pattern. As the study is not a survey, a few (2-3) sampling points are usually sufficient to indicate the dynamics of a particular wetland.

The location of sampling points is pinpointed on aerial photos. The wetland is further documented with ground-level and low-level oblique photographs.

2. *Peat Sampling* - Peat is cored with a minimized McCauley corer. The inside diameter of the corer is 35 mm. This sampler is similar in principle and construction to the Russian peat sampler noted in the Scandinavian literature (cf. Tolonen 1979). The small diameter of this sampler makes this tool readily portable, and allows penetration into various densities of peat. The samples are relatively undisturbed and suitable for bulk density determination.

The entire peat column and the top of the underlying mineral soil is cored. Samples are taken at 15 cm intervals or more frequently when changes in the peat are noted. An 8 cm section is saved for bulk density, moisture and chemical analyses, and a 7 cm section is kept for macrofossil analysis. A sample of the underlying mineral soil is also collected. The pH of the sample is determined in the field with a dual pH paper. The decomposition class of the peat is estimated by the von Post method on part of the macrofossil sample.

3. *Vegetation Studies* - The size and number of plots at each site vary with the broad vegetation type. In treed and high shrub areas 5 m x 5 m plots are laid out, usually 1-2 per vegetation unit. In grassy or low shrub areas five 1 m^2 plots are established. Transects are laid out to study the transition between vegetation types. The transect consists of a string of 0.25 m x 0.25 m plots.

All species are identified in the field and their abundance is estimated. Voucher specimens of doubtful species are collected to verify their identification. Cores are taken at stump height from trees of all size classes for age determination.

4. *Hydrology* - The surface topography of the wetland is determined with a hand level instrument to establish the direction of water movement. A sample of the groundwater is taken from a shallow pit dug for the purpose. Surface water from fens or from natural hollows is also collected. The pH is measured in the field, as the water samples have very little buffering capacity and the pH is subject to change as time elapses.

Laboratory Studies

1. *Physical Properties* - The following determinations are made on all samples collected during the field season, using standard methods outlined in McKeague (1978):

Volumetric moisture content
Gravimetric moisture content
Bulk density
Ash content (dry ashing at 480°C)

On selected samples the following determinations are made:

Radiocarbon age
Calorific value
Decomposition (pyrophosphate)

2. *Chemical Analyses* - Total elemental analysis of all peat and water samples is performed with an Inductively Coupled Argon Plasma Atomic Emission Spectrometer (ICAP-AES). The samples are prepared by dry ashing and nitric acid digestion. The following elements are identified:

Al, Ca, Cu, Fe, K, Mg, Mn, Na, Ni, P, Pb, S, Zn

3. *Biological Properties* - Recognizable macrofossils of all samples are identified at least to the genus level. Selected bryophytes, such as Sphagnum and Drepanocladus are identified to species whenever the condition of the sample allows. A measure of abundance is given by a scale of relative abundance of each genus or species in the peat sample. Mollusks are identified to the genus level.

PRELIMINARY RESULTS

In 1981 a total of 52 different wetlands were investigated in central Alberta. The following wetland types were included:

BOGS

7 Basin bogs
6 Flat bogs
5 Fen window bogs
3 Frost mound bogs
2 Northern plateau bogs
1 Bog island
1 Bowl bog
1 Pond marginal bog

FENS

12 Northern ribbed fens
4 Horizontal fens
3 Basin fens

SWAMPS

3 Peat margin swamps
2 Stream swamps

FROZEN PEATLANDS

1 Palsa
2 Peat plateaus

A total of 1428 peat samples were collected from 78 coreholes, and 152 surface and groundwater samples were taken. The average depth of peat was 2.84 m, ranging from 84 cm to 756 cm. The pH of the peat showed great variation from the minerotrophic fens (max. 7.1) to oligotrophic bogs (min. 3.6). The calorific value of the peat was also variable, ranging from a low of 3913 cal/g to 5223 cal/g, averaging 4634 cal/g, without a clear relationship to botanical origin, or degree of decomposition. However, the higher solids content of the better decomposed peat at about 1.15 g/cc contains higher calorific values than the light fibric peats at a solids content of about 0.9 g/cc.

The rate of peat accumulation was calculated with the aid of radiocarbon dates and volcanic ash marker horizons (Mazama ash, St. Helens Y ash). Preliminary indications are that treed bogs and fens produce slightly less peat at 50.04 $g/m^2/yr$ than shrubby or open fens at 60.98 $g/m^2/yr$. As these figures are not corrected for ash content, final caluclations may show somewhat lower accumulation rates and more diversification among the vegetation types that produced the peat. In terms of height increment, the mean annual peat accumulation was 0.55 mm/yr in the treed bogs and fens, and 0.58 mm/yr in the treeless fens.

On the basis of macrofossils, 10 vegetation types were identified that contributed to peat building. Further subdivisions can be made on the basis of moss species that reflect the trophic levels and hydrology of the peat-forming vegetation communities.

An analysis of the plant communities throughout the peat column sheds light on the development of the peatlands. Taking the northern ribbed fens as an example, the question of the permanence of the ridges can be examined. Of the 12 ribbed fens examined, nine showed that the flarks were more water-logged than the ridges for at least half the thickness of the section. In three areas the drier conditions on the ridges is apparent only in the top metre of the peat section. The differences in moisture conditions on the ridges and in the flarks are manifested in several ways. Often forest peat or shrubby fen peat is found on the ridge, in contrast with shrubless fen peat in the flark. In several cases open pools existed in the flarks as shown by marl and mollusk shells, but not under the ridges where shrubby fen vegetation persisted. Indications are that the ridge-flark pattern can be maintained for thousands of years, but it is a process that can be initiated at any time during the life of a fen.

The vegetation studies identified 10 community types. Floristically the fens are far richer in species than the bogs. During the field work, some 150 different vascular plant species, 85 species of mosses, 20 species of liverworts, and 40 species of lichens were collected. The known range of several liverworts were significantly extended, and one liverwort was new to Alberta. Similarly, one tree lichen was found that was previously unreported in Alberta.

The present study is a broadly-based analysis of the dynamics of peatlands. Already, much informtion has been gained on the development, persistence, and stability of various peatland forms, and on the hydrologic and nutritional conditions required for their development. Future studies in the boreal zone of Manitoba and Saskatchewan will undoubtedly reveal further important data on the dynamics of peatland development.

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MINNESOTA'S PEATLAND INVENTORY

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ABSTRACT

The Minnesota Peat Inventory Project is currently surveying the State's large peat reserves. The State initiated the inventory because of the absence of suitable resource information for management decisions. The size of many of the peatlands, accessibility problems, and financial and time constraints have dictated the method used to inventory and map the peatlands. Survey work has concentrated on an area in northern Minnesota where approximately 1.6 million hectares of the state's estimated 2.4 to 2.8 million hectares of peatland occur. The staff collects resource information at sites located along traverses or at scattered, selected sites to obtain data to characterize the peat resource. The data are plotted and isarithmic mapping is used to identify areas of equal peat thickness. The printed maps emphasize fuel-grade peat deposits, as defined by the U.S. Department of Energy, and deposits of sphagnum moss peat, valued for horticultural use.

RÉSUMÉ

Le projet d'inventaire des tourbières du Minnesota effectue présentement un relevé des énormes réserves de tourbes de cet État. Celui-ci a mis sur pied le projet à cause de l'absence d'information appropriée sur cette ressource, information nécessaire à des prises de décision en matière de gestion. La superficie de bon nombre des tourbières, les problèmes d'accessibilité et les contraintes financières et temporalles ont dicté les methodes utilisées pour inventorier et cartographier les tourbières. Le travail de prospection s'est concentré sur une région d'environ 1.6 millions d'hectares de tourbières situées au nord de l'État qui en compte 2.4 à 4.8 millions. Le personnel recueille des informations à des emplacements situés le long de cheminements où à certains endroits dispersés pour obtenir des données nécessaires à la caractérisation de la ressource en tourbe. Les données sont ensuite portées sur un graphique et la cartographie isorythmique sert à identifier les zones d'égale épaisseur de tourbe. Les cartes d'égale épaisseur de tourbe. Les cartes imprimées laissent entrevoir des dépôts de tourbe combustible, définis par le ministère de l'Energie des Etas-Unis, et des dépôts de mousse de spnaigne recherchés en horticulture.

INTRODUCTION

The Minnesota Peat Program began in 1975 in response to a peatland lease request by a Minnesota utility. The Minnesota Gas Company (Minnegasco) requested a lease of approximately 741 000 hectares, of which about 494 000 hectares were primarily state-administered peatland, to produce substitute natural gas from peat. Because little was known about the State's peat resource, the Peat Program initiated work in two areas: (1) studies evaluating environmental, social and economic consequences associated with development, and (2) an inventory of the State's fuel and horticultural peat resource.

To date, over 40 studies have been completed on a variety of topics. The studies have examined baseline environmental conditions, vegetation, wildlife, potential uses, socio-economic conditions, leasing and reclamation. Funding for the studies and for the initial inventory work was received from the Upper Great Lakes Regional Commission, the Minnesota Legislature, the Legislative Commission on Minnesota Resources, and the National Science Foundation.

The Minnesota Peat Inventory Project (MPIP) began in 1976, but was accelerated in 1979 when the U.S. Department of Energy (DOE) awarded a grant to the State of Minnesota to

determine the State's fuel-grade peat reserves through survey and the collection of energy-related data. A year later, the grant was amended to include partial funding from the Gas Research Institute, a non-profit corporation founded in 1978 to fund coal gasification and fossil fuel research, funded by the American Gas Association.

MINNESOTA'S PEAT RESOURCE

Minnesota contains approximately 2.4 to 2.8 million hectares of peatland. Deposits are found throughout the State, except in the extreme southwest and southeast. Large, contiguous deposits occur in the northern half of the State, while the smaller, scattered deposits are found mainly in the southern half (Fig. 1). The largest peatlands formed by paludification on the lake plains of Glacial Lakes Agassiz, Upham and Aitkin. Most of the smaller peatlands formed in morainic depressions and on outwash plains.

The occurrence of raised bogs (sphagnum moss peat is used as both an industrial chemical feedstock and as a horticultural resource) in the State is restricted to the peatlands of northeastern and north-central Minnesota. Estimates indicate that only 2% of the State's peatlands contain significant deposits of sphagnum moss peat (Malterer *et al.*1979).

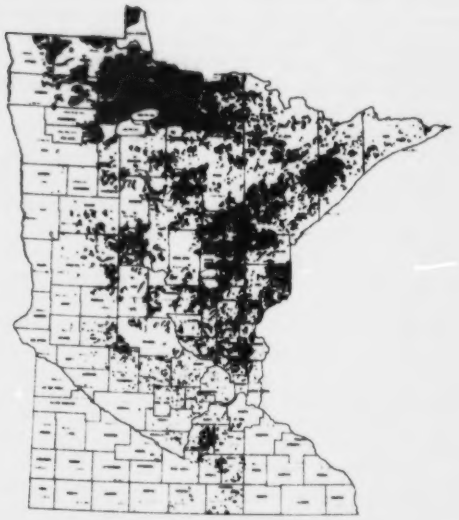
PEAT RESOURCE INFORMATION

Before the inception of the Minnesota Peat Inventory Project, limited peatland resource data were available for northern Minnesota. Two data sources, the Soil Atlas Project and Soil Conservation Service county soil surveys, provide reasonably accurate information on the areal extent of peatlands; however, their use for estimating the volume of the State's peat resource is restricted due to the limited information they provide on peat depths.

The Soil Atlas Project, developed by the University of Minnesota's Soil Science Department in conjunction with the Minnesota Geological Survey and the U.S. Department of Agriculture's Soil Conservation Service, provides the only soils information with state-wide coverage. The purpose of the Atlas project was to provide general information for planning purposes, particularly in areas with no other soils data.

The project consists of a series of eleven map sheets, published at a scale of 1:250,000 with accompanying texts. The organic and mineral soils were mapped by air photo interpretation to a level of detail approximately equivalent to the subgroup category of the Seventh Approximation of Soil Taxonomy. The use of the series to identify specific resource characteristics or for calculating peat reserves is limited, however, because of the constraints imposed by the map scale and by the level of detail of the original survey.

Figure 1. Peatland distribution in Minnesota.



The amount of generalization associated with a small map scale resulted in the mapping of soils to a resolution of about 640 acres. Therefore, mapping units contain inclusions of other soil types. The level of detail at which the organic soils were mapped changed over the course of the project. On the first two maps in the series the organic soils are undifferentiated by type and depth. The differentiation of depth of the organic soils was based on a 125 cm control section (Rust *et al.* 1976). Depths of the organic soils were estimated by interpreting the relief of the surrounding uplands from air photos and limited field checking. Organic soils were mapped as "shallow" if the thickness of the organic material was less than 125 cm. The use of this series for peat resource estimation is limited because no maximum depth is given for the organic soil mapping units.

Another source of peatland data are U.S. Department of Agriculture, Soil Conservation Service county soil surveys. In northern Minnesota, the coverage for areas with extensive peat deposits is limited to Carlton County (Lewis 1978) and the Kawishiwi Area (Prettyman 1978). Soil surveys can be used to identify the distribution, areal extent,

and type of peat found in a county; however, the use of soil surveys for calculating peat reserves is limited by the criteria chosen to identify the maximum thickness of the deposit. The Soil Survey Staff (1975) arbitrarily established the control section for taxonomy of organic soils at 130 or 160 cm thick, depending upon the kind of material in the deposit. The depth of the shallow organic soils falls within the depth of the control section. There is no maximum depth given for organic soil deposits exceeding 160 cm in thickness. An example is the Waskish Series mapped in Carlton County. This organic soil can be 300-600 cm thick, according to the soil description, but in any given location within the county we only know that the soil is greater than 160 cm thick, the depth of the control section (Lewis 1978).

MPIP SURVEY

The Minnesota Peat Inventory Project (MPIP) is a response to the need for more detailed peat resource information, especially an estimation of the depths of deposits. Its purpose is to identify fuel-grade peat and horticultural peat in northern Minnesota. Fuel-grade peat, as defined by the U.S. Department of Energy: (1) has an energy value of 8,000 Btu/lb or more per profile in an oven-dry state, (2) contains less than 25% ash, (3) occurs in deposits that are at least five feet deep, and (4) covers a cumulative area of more than 80 acres per square mile.

The inventory is a reconnaissance-level survey to estimate the quantity and quality of the State's peat resource for policy and management planning decisions. The survey is not designed to provide site-specific data; rather it identifies peatlands that require more detailed mapping if they have development potential.

Field work and laboratory analysis constitute the two major inventory functions. The field work includes data collection on the physical characteristics of the peat deposit and sample collection. The peat samples are analyzed to determine both physical and chemical properties of the peat that indicate potential for energy and horticultural use.

The survey findings for an area are presented in a technical report that includes a text and an accompanying map of the resource. The publication describes the location, quality, and quantity of the peat resource, the chemical and physical properties of the peat, the distribution of fuel-grade peat, and the estimated energy potential of the peat.

Field Work

The survey of the peat resource in an area begins by mapping the surficial geology. Geomorphic features and surface materials are identified by interpretation of 1:90,000 leaf-off air photos. The boundaries are delineated on 1:63,360 scale county highway maps. Large scale, 1:20,000 photographs are used if more detail is required. U.S. Geological Survey 1:24,000 (7.5 minute) quadrangle maps provide an additional reference for delineating the geologic boundaries.

The surficial geology mapping units include depositional and erosional features, such as ground moraine, end moraine, glacial lake sediments, remnant beach ridges, kames, eskers, and rock outcrops. Within peatlands, water tracks, patterned fens, teardrop-shaped islands, raised bogs, and ovoid islands are located and sketched on the map.

The field crews examine the surficial geology map in conjunction with 1:90,000 aerial photographs and U.S.G.S. quadrangle and orthophoto quadrangle maps to identify the location and areal extent of the deposit, access points to peatlands, and the location of raised bogs.

During the peatland survey, data are collected along traverses or at selected, scattered sites to characterize the resource. When access permits, the primary traverse is along the major axis of the peatland. Secondary traverses are selected that are perpendicular to the primary traverse or that are perpendicular to the slope of the peatland. In peatlands where the surface expression of features appears similar, such as a cluster of ovoid islands, one island is surveyed in greater detail, and the data are extrapolated to the surrounding islands.

Because of the size and accessibility constraints of many of the peatlands, and because of financial and time constraints of the inventory project, it is not feasible to survey all peatlands by traverses. Access to the Red Lake Peatland, for example, restricted the use of traverses in some areas of the peatland. The peatland is very large, approximately 15 by 80 kilometres, and contains a ditch network impassable by all-terrain vehicle that was constructed at one- and two-mile intervals during the early 1900's. Heavy forest cover and fens that contain scattered, stunted black spruce or tamarack limited helicopter access.

In areas where traverses are not used, peatland

data are collected at selected, scattered observation sites. The MPIP staff selects sites that are representative of distinctive peatland landforms or that indicate possible relationships between a peatland and specific mineral features, such as a peatland delimited by a remnant beach ridge or a peatland that formed within a morainic depression.

The density of observation sites, whether along a traverse or scattered within a peatland, depends on the following factors: (1) access to the peatland, (2) knowledge of the post-glacial topography, (3) homogeneity of the deposit, and (4) the type of peatland feature surveyed (for example, because of the finite nature of Minnesota's horticultural peat reserves, the density of observation sites on raised bogs is greater than in fens or swamps).

At each observation site reached, whether by traverse or at selected points, the field crew describes the peat profile, the peatland vegetation, the micro-relief, and the depth to the water table. The profile description includes the degree of decomposition, using the von Post system, and the botanical origin of each layer within the profile. Each site location and its profile description are plotted on 1:24,000 U.S.G.S. quadrangles for later interpretation.

Representative raised bogs, fens, and swamps are then empirically selected for sampling. Sites are chosen by air photo interpretation and by interpretation of the observation site data.

The field crew uses power-driven and manual Macaulay samplers to collect samples for laboratory analysis. Two profiles at the same site are sampled. One set of samples is analyzed by the MPIP staff for ash, water content, bulk density, and pH determinations. The second set of samples is analyzed at a DOE laboratory for energy value (Btu/lb), proximate analysis (moisture, volatile matter, fixed carbon, and ash), and ultimate analysis (carbon, hydrogen, nitrogen, sulfur, oxygen, and ash).

Production of Peat Resources Maps

The Peat Resources map series of the MPIP survey work is designed to emphasize peatlands meeting the DOE criteria for fuel-grade peat and to identify deposits with a high potential for horticultural use. The MPIP staff developed mapping units to differentiate peat depth, degree of decomposition, and the botanical origin of the deposits. Inclusions occur within the mapping units due to: (1) generalization during map compilation and production, (2) the density of the peatland observation sites, and (3) the map scale.

The staff differentiates the depth of the peat deposits by isarithmic mapping. Peat isolines are drawn with an interval of 150 cm on the U.S.G.S. quadrangles. The lines are drawn by interpretation of the plotted observation site data, which serve as control points, and by interpretation of stereo-pair aerial photographs. A second set of isolines differentiates the depth of the relatively undecomposed sphagnum moss peat cap units (von Post H1-H3). These isolines, with class intervals of 20-60, 61-150, and 151-300 cm, are drawn on the same quadrangles and are also based on the observation site data and air photo interpretation.

The quadrangles are then reduced to 1:126,720 so the peat delineations can be transferred to the base map. The MPIP uses the county highway maps, produced by the Minnesota Department of Transportation, as base maps. Boundaries between the mineral and organic soil units are transferred from the surficial geology map to the county highway base map to show the areal extent of the peatlands.

Peat resource mapping units are differentiated by color and pattern on the published maps. Mineral soils are portrayed in gray; peat deposits less than 150 cm deep, thus not meeting DOE's depth requirement for fuel-grade peat, are indicated by light orange; peat deposits meeting the DOE fuel-grade peat requirements are indicated by dark orange; and accumulations of relatively undecomposed sphagnum moss peat are indicated by a stipple pattern. Further separations by depth are made within the fuel-grade peat units by labeling the individual mapping units. The following upper-case letters indicate total depth of peat:

A	0-150 cm
B	151-300 cm
C	301-450 cm
D	451-600 cm

The total depth designation used alone (e.g. A) denotes a moderately decomposed peat. The total depth designations used in conjunction with a lower-case letter (e.g. Aa or Ax) indicates either (1) a relatively decomposed sphagnum moss peat cap overlying moderately decomposed peat or (2) a deposit of well decomposed peat.

The sphagnum moss peat cap unit is subdivided by depth:

a	20- 60 cm
b	61-150 cm
c	151-300 cm

The cap unit designations are always used in conjunction with a total depth designation (e.g. Aa): the peat unit has a total depth indicated by the upper-case letter (e.g. A 0-150 cm) and has a surface layer of sphagnum moss peat to the depth indicated by the lower-case letter (e.g. a 20-60 cm). Moderately decomposed peat generally comprises the rest of the profile.

A lower case x following a total depth designation (e.g. Ax) indicates that the entire profile of the specified depth consists of well-decomposed peat.

Pine Island Peatland -- An Example of the MPIP Survey Work

The survey of Pine Island peatland, located in Koochiching County in northern Minnesota, provides an example of the MPIP work in a specific area. The peatland formed by paludification of the lacustrine plain of Glacial Lake Agassiz. To the north, the peatland is bounded by a remnant beach ridge. Scattered mineral islands, composed of beach material and lakewashed ground moraine, occur within the peatland (Fig. 2). The peatland vegetation type is raised bog in the north and fen in the south.

The field crew had access to the peatland along winter logging trails by using all-terrain vehicles. Observation and sample site data were collected along traverses that cross the raised bog and fen and at scattered points within the peatland (Fig. 2a). After collecting the field data, the MPIP staff delineated the thickness of the deposit by interpolating between the site data, used as control points, and by interpreting air photos (Fig. 2b). A second set of isolines delineate the sphagnum moss peat cap of the raised bog (Fig. 2c). The finished map contains both sets of isolines: the sphagnum moss peat cap contours are superimposed on the total depth contours (Fig. 2d). Figure 2d is an example, done in black and white instead of color, of the Peat Resources maps produced by the MPIP. The figure identifies the location of the sphagnum moss peat resources with a stipple pattern, but differentiates the peat depth by label only, rather than by label and color.

The MPIP survey found that the Pine Island peatland is composed of a thin basal layer of highly decomposed peat overlain by moderately decomposed peat. The peat in the raised bog is composed mainly of relatively undecomposed sphagnum moss to a maximum depth of 180 cm. The total peat accumulation in the peatland ranges from 0-600 cm deep.

Resource Estimation

To provide estimates of the areal extent of the surveyed peat deposits, the Peat Resources maps are digitized at the published scale (1:126,720) and the data are entered and stored as a data base in the Minnesota Land Management Information System (MLMIS) of the Minnesota Department of Energy, Planning and Development. MLMIS is a statewide data base of a large number of cultural and physical variables to be used in guiding the management of Minnesota's resources. After editing and conversion to a cell file, the resource data are processed to yield acreage counts for each mapping unit. Estimated tonnages of oven-dried peat are calculated by multiplying the volume of each mapping unit by the average bulk density of the type of peat, where the volume equals the areal extent of the mapping unit times its average depth. The energy potential of mapping units exceeding 150 cm in depth is then calculated by multiplying the tons of peat for the mapping unit by the average energy value for the type of peat, measured in British thermal units (Btu).

The laboratory analyses performed to date on samples obtained by the MPIP staff indicate that all of the peat deposits that are at least 150 cm deep and cover an area of more than 80 acres per square mile meet the energy value and ash requirements set by the DOE for fuel-grade peat; that is, the peat has an energy value exceeding 8,000 Btu/lb and the ash content is less than 25%.

Associated Uses of MPIP Resource Data

The Minnesota Peat Program staff is currently developing a process to guide peatland management decisions for a variety of potential uses, including extractive, non-extractive, or preservation options. The initial stage of the process is a regional analysis and uses an automated overlay mapping technique to combine peat resource data with the environmental and socioeconomic factors associated with the potential uses. Through this process potentially suited peatlands are identified for more detailed, site-specific work. The encoded MPIP resource information provides the data on areal extent, depth, and type of peat. Because the data are part of the MLMIS data base, the peat resource data can be combined with other variables stored in the system to determine possible ownership constraints, accessibility constraints, water proximity, and vegetation cover of the peatlands. The results of the

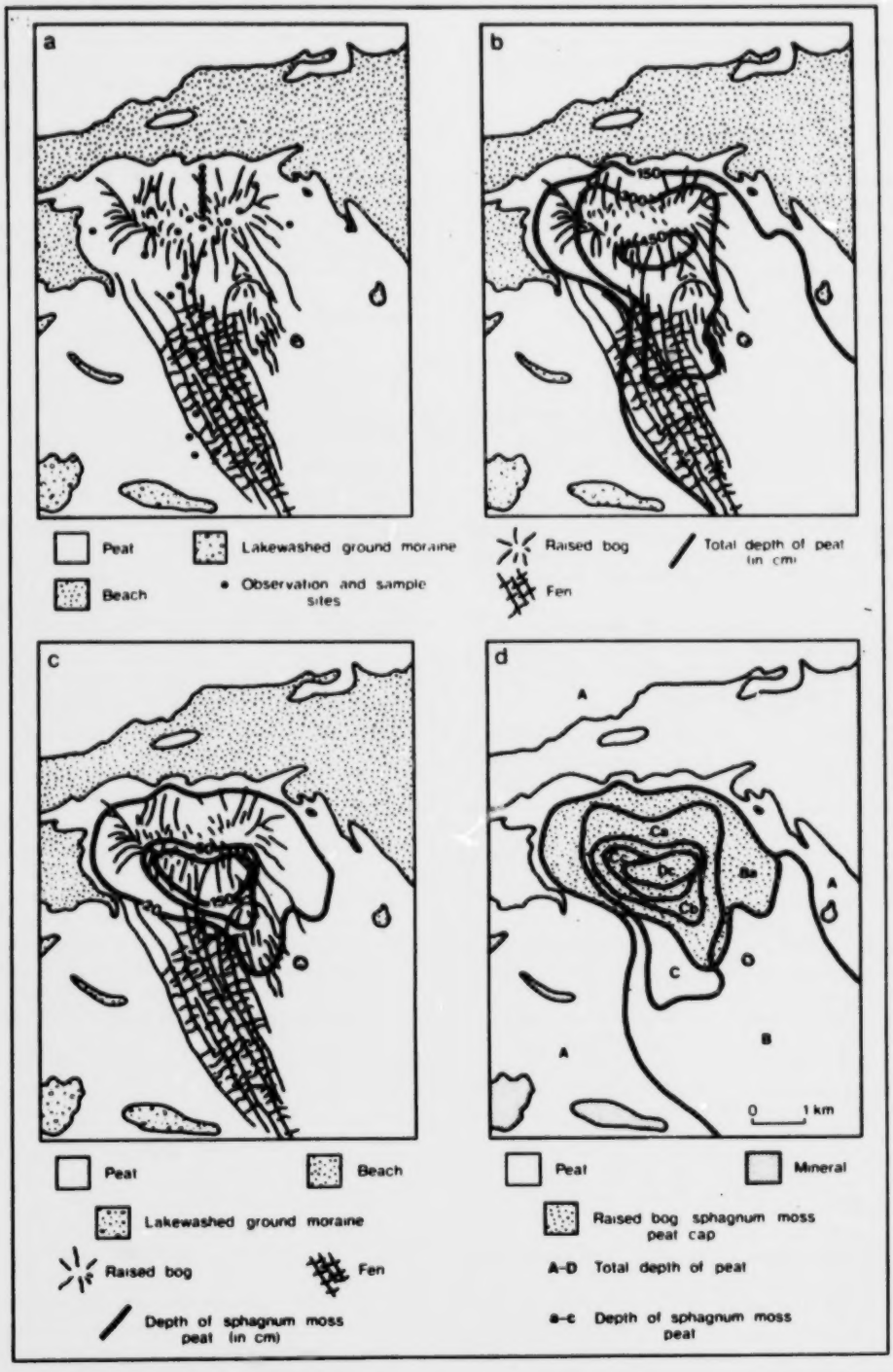


Figure 2: Pine Island Peatland. (a) Surficial geology, peatland patterns, and observation sites. (b) Total depth of peat delineations. (c) Sphagnum moss peat delineations. (d) Completed map, using MPIP legend for depth and type of peat (explained in the text).

regional analysis are displayed in mapped and tabular form for further map and statistical analysis.

CONCLUSIONS

The Minnesota Peat Inventory Project has completed the survey and has published the results for southwest St. Louis, Koochiching, and Aitkin counties. The three areas contain approximately 748 000 hectares of peatland, of which approximately 244 000 hectares or 33% of the peatlands meet the U.S. Department of Energy criteria for fuel-grade peat. Approximately 51 000 hectares or 7% of the peatlands in the area contain sphagnum moss peat deposits.

Peatland surveys are in progress in five other counties in northern Minnesota. When these surveys are completed, the Minnesota Peat Inventory Project will have surveyed approximately 1.6 million hectares of the State's 2.4 to 2.8 million hectares of peatland and will have identified the peatlands with the greatest potential for energy and horticultural development.

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PEATLAND INVENTORY METHODOLOGY USED IN SOIL SURVEYS

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ABSTRACT

The inventory methodology used by Soil Survey for mapping peatlands in Canada is based on the use of the peat landform. These landforms (bogs, fens, swamps and marshes) provide an overall framework for establishing map units. The survey methodology, beginning with the photo interpretation, followed by field data collection and the creation of a peatland map with legend, is described and illustrated as is the type of analytical data needed to support this inventory. Areas mapped at different intensities of surveys are indicated on a map. The areal extent of peatlands derived from the CanSIS computerized data bank, which is based on the distribution of soils in Canada, was determined. It was found that the Northwest Territories has the largest area of peatlands (25 111 100 ha) in Canada, followed by Ontario (22 555 100 ha) and Manitoba (20 664 200 ha). The largest concentration of peatlands is found in Manitoba (38% of the land area of the Province) followed by Ontario (25%). Almost one-quarter (23%) of the total Canadian peatlands are found in the Northwest Territories, followed by Ontario (21%) and Manitoba (19%). Gaps in peatland inventories and in the data are identified and areas for future peatland studies are suggested.

RÉSUMÉ

La méthodologie d'inventaire utilisée par la prospection pédologique pour la cartographie des tourbières au Canada s'appuie sur l'utilisation du relief des tourbières. Cette topographie (tourbières, fens, marécages et marais) fournit une infrastructure globale pour l'établissement des unités cartographiques. La méthodologie de prospection qui commence par l'interprétation des photos, et est suivie par la collecte de données sur le terrain et la création d'une carte des tourbières avec légende, est décrite et illustrée, tout comme le type de données analytiques nécessaires pour appuyer cet inventaire. Les régions cartographiées à diverses intensités de prospection sont indiquées sur une carte. On a ainsi pu déterminer la superficie des tourbières à partir de la banque de données informatisées CanSIS basée sur la distribution des sols au Canada. On a découvert que les Territoires du Nord-Ouest possédaient la plus grande superficie de tourbières (25 111 100 ha) au Canada, suivis par l'Ontario (22 555 100 ha) et le Manitoba (20 664 200 ha). Notre plus grande concentration de tourbières se retrouve au Manitoba (38% de la superficie de la province), suivi par l'Ontario (25%). Près du tiers (23%) de toutes les tourbières canadiennes se retrouvent dans les Territoires du Nord-ouest, suivis par l'Ontario (21%) et le Manitoba (19%). On identifie actuellement certaines lacunes dans les inventaires de tourbières et dans les données correspondantes, et on suggère des régions propices à de futures études dans ce domaine.

INTRODUCTION

Mapping of organic soils is part of Soil Survey's inventory mandate in Canada. In surveys carried out prior to 1960 peatlands were mapped simply as organic areas or identified as peat or muck soils. In the early 1960's the study of taxonomic classification of organic soils began and, as a result, more attention was paid to differentiating peatland types and peat deposits. Peatlands were mapped as either deep or shallow peat and subdivided according to the dominant peat materials (Smith and Ehrlich 1964).

In the late 1960's attention focussed on peat landforms as the basis for mapping units. The peat landform classification was developed first in Manitoba (Tarnocai 1970) and then expanded into other parts of the country. This class-

ification was recently incorporated into the national wetland classification (Tarnocai 1980), which presently provides the basis for peatland mapping.

In this paper a brief description of the peatland inventory methodology used by Soil Survey is given together with the area covered by these surveys and the identification of areas in Canada where basic peat resource data is lacking.

INVENTORY METHODOLOGY

The method of mapping peatlands and organic soils in soil surveys differs from the method used in mapping mineral soils mainly in that the peatland mapping relys much more heavily on the landform (peat landform). Another difference (especially in recent peatland surveys) is that the information relates to the whole peat deposit and to the mineral soil below the basal peat instead of just to a depth of about one metre, as is usually the case in soil surveys of mineral terrain.

The information contained in these peatland inventories relates mainly to the peat deposit since they are inventories of the peat or the organic soil resource. Surface factors (e.g. vegetation) appear only in descriptive terms. Since, however, the peat landform provides the basis for the mapping unit and the vegetation is closely related to the peat landforms, the vegetation plays an active part in the formulation of the map unit.

Peat Landforms as a Basis for Mapping

The peat landform is one of the most stable and easily recognizable components of the peatland environment. It provides a single expression in which all physical and biological factors are integrated.

The peat landform classification used by Soil Survey is shown in Table 1. This classification is part of the wetland classification included in the Canadian Wetland Registry (Tarnocai 1980). The peat landforms are primarily named according to either their surface morphology, their surface pattern, the morphology of the basin in which they have developed or their association with water bodies. They can be recognized on the ground, from the air and on remote sensing data. They represent such typical biotic and abiotic components as vegetation, hydrology, peat materials and stratigraphy of the peat deposit, thermal condition and soils. This is shown in Figure 1.

The peat landforms indicated in Table 1 form the basis for the mapping. The map units associated with these peatlands represent areas having similar peat landforms and soil properties. These soil properties vary within narrow limits, the exact range depending on the intensity of the survey. The peat landform, however, provides an overall framework for establishing map units.

Because the peat landform classification is hierarchical in structure, it permits the recognition of local landform units for most scales of mapping. At the class level general peat landforms (bogs, fens, swamps and marshes) provide a useful basis for mapping at small scales, usually less than 1:250,000, while at the form level local peat landforms (e.g. basin swamp) are the most useful basis for medium and larger scale mapping (1:250,000 to 1:25,000).

Landforms provide a natural basis for establishing mapping units in peatlands because they reflect uniform ecological conditions. This uniformity in ecological condition is reflected in the vegetation communities they support and in the compositional nature of the peat deposit itself. This uniformity also permits a much higher degree of confidence in the mapping of relatively inaccessible peatlands, requires less dependence upon ground truthing, lends itself to air photo and other remotely sensed imagery interpretations and, finally, reduces the cost and time required to conduct such a survey.

The incorporation of the landform and the associated soil and vegetation descriptions into mapping unit descriptions greatly enhances the possibilities and usefulness of interpretations for biologically oriented fields such as agriculture, forestry and wildlife habitat characterization. The identification of a landform type, together with knowledge of its properties, is very useful for engineering interpretations, trafficability studies, and prediction of physical conditions to a considerable depth. The close relationship between landform and peat material enhances such interpretations.

Inventory Methodology Used by Soil Surveys

Most peatland mapping relies heavily on remote sensing information. Although black and white panchromatic aerial photographs are still widely used, color and infrared aerial photography and satellite imagery increasingly are being used in mapping.

Photo interpretation of peatlands usually begins with the analysis of the patterns on these photos. The most common and most important

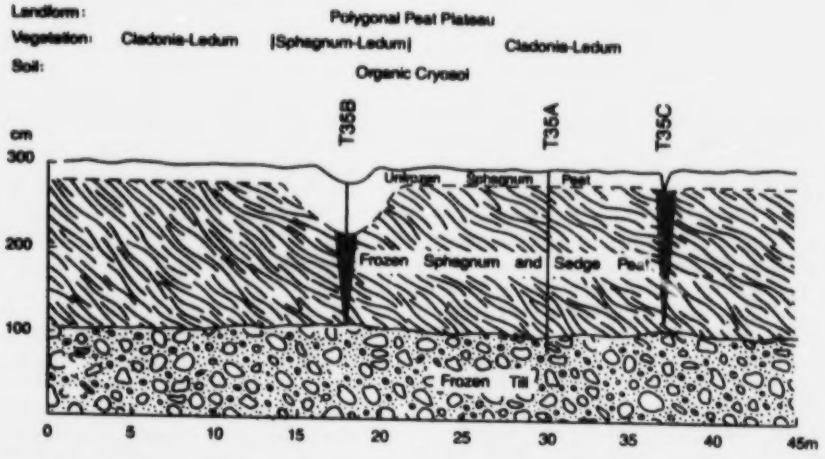


Figure 1: Aerial view of a polygonal peat plateau with a cross-section indicating the vegetation types, permafrost conditions and ice wedges. The sampler holes are identified by their numbers (T35A, T35B, T35C).

Table 1: Peat landform classification used in soil surveys (Tarnocai 1980).

BOG	FEN	SWAMP	MARSH
Palsa	Northern Ribbed	Stream	Floodplain
Peat Mound	Atlantic Ribbed	Shore	Inactive Delta
Mound	Ladder	Peat Margin	
Domed	Net	Basin	
Polygonal Peat Plateau	Floating	Flat	
Lowland Polygon	Stream	Floodplain	
Peat Plateau	Shore	Spring	
Atlantic Plateau	Collapse		
Collapse	Palsa		
Floating	Spring		
Shore	Slope		
Basin	Lowland Polygon		
Flat	Horizontal		
String	Channel		
Blanket			
Bowl			
Slope			
Veneer			

pattern elements of the natural landscape for interpretation are landforms, vegetation and drainage. The energy which is responsible for creating the image on the film material is mainly reflected from the vegetation canopy. Stereoscopic examination of these images makes possible the identification of peat landforms, vegetation and drainage. Soils and associated peat materials can be interpreted using the peat landform in conjunction with the ground truth data. Since the peat landform plays an important role in the interpretation of peatlands, a great deal of work has been carried out in identifying peat landforms on aerial photographs (Tarnocai 1970, 1972, 1974 and Mollard 1972).

The preliminary map and accompanying legend generated from this photo interpretation serve as the basis for the field work. Using this preliminary map, sites which will be visited during the field work are selected. In earlier surveys point checks were made at selected locations within a map unit. In more recent surveys the information is often collected along one or more transects crossing representative portionsof the peatland.

Information collected by either of these sampling methods includes detailed examination and sampling of both the peat deposit and the underlying mineral material by use of a peat sample.

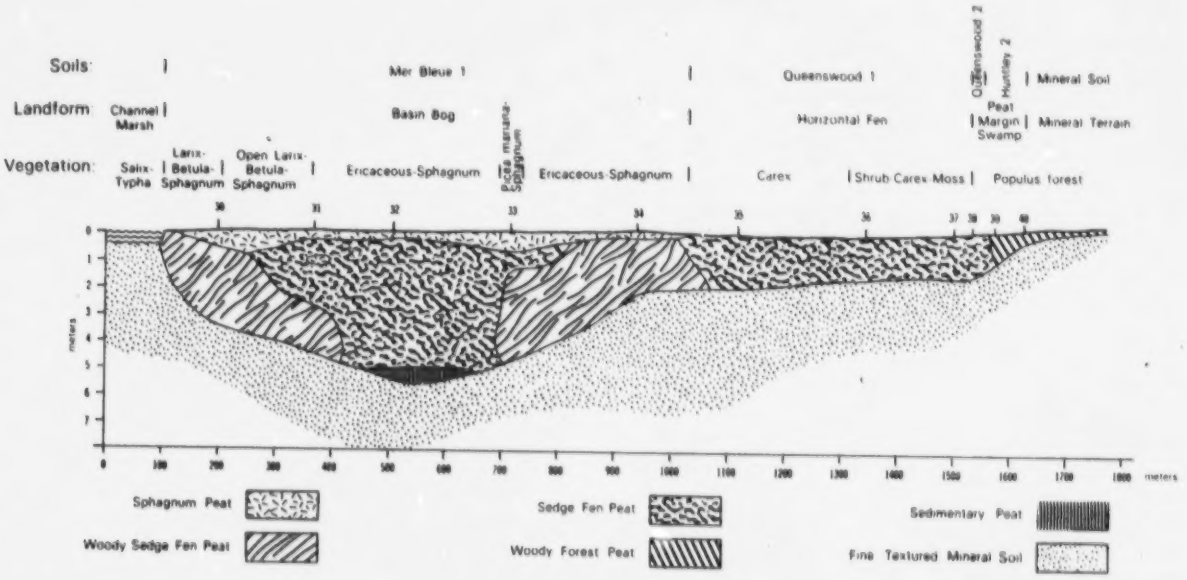
For the field data, the color, degree of decomposition, boundaries, structure, consistence, wood content, amount of roots and the type of peat materials are determined for the various peat layers. The peat materials are classified according to their botanical composition. Peat landforms, organic soils, drainage and the vegetation are also described.

Peat samples collected during the field work are subjected to laboratory analyses. The analytical data include the physical and chemical characteristics of the peat. These generally consist of the rubbed and unrubbed fibre content, ash content, pyrophosphate index, pH, organic carbon percent, total nitrogen, bulk density, exchangeable cations, and cation exchange capacity. These analyses are carried out as specified in the publications of the Canada Soil Survey Committee (1978) and the Subcommittee on Methods of Analysis (1978).

The field information is collected along transects which have been measured and leveled. The position of sample holes, the boundaries of peat landforms, the boundaries of the various vegetation types, and the thicknesses of the various peat layers are recorded during the survey. This transect information enables the compilation of an accurate cross-section diagram of the peatland. The cross-section diagram indicates not only the surface features but also the distribution and type of both the peat layers and the underlying mineral material (Figure 2).

The transect information also provides the data necessary for checking the map units generated

Figure 2. Cross-section A to B (see Figure 3), located in the Mer Bleue peatland. The sampler holes are identified by their numbers (30, 31, etc.), and their locations are indicated on the cross-section.



during photo interpretation. In addition, the information obtained from the transect establishes the relationships between peat landforms, peat materials, vegetation, drainage and soils. These relationships form the basis for the peatland map and associated legend (Figure 3). Using the information presented in the peatland map and the cross-sections of the various peatland types, peat volumes can be calculated for the total peat and the various peat materials of which these deposits are composed.

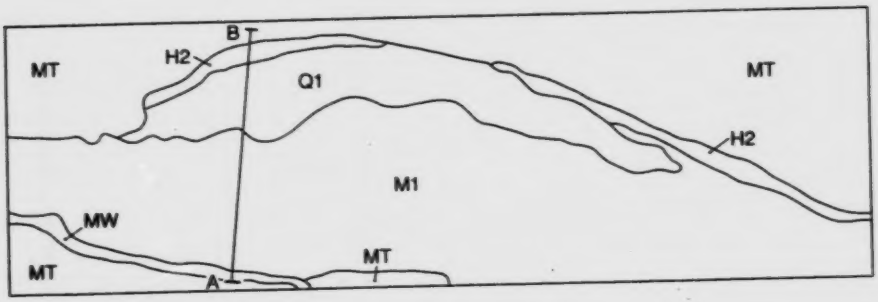
Since most of the peatlands are inaccessible, field data collection is generally carried out with the aid of helicopters or tracked vehicles (J-5 Bombardiers). If a helicopter is used, locating suitable landing sites is often a problem, especially on treed bogs. Landing sites are usually located on fens from which foot traverses are made to the neighbouring bogs. In northern Alberta and the Mackenzie Valley landings are made along seismic lines resulting from oil exploration.

Examples of the type of peatland inventory maps generated in Canada by the Soil Survey are found in the works of Tarnocai (1975), Mills *et al.* (1977), Schut *et al.* (1979) and Turchenek (in press).

AREA MAPPED BY SOIL SURVEYS

The areas of Canada where soil survey inventories were carried out prior to January 1980, are indicated in Figure 4. This composite map includes detailed and reconnaissance surveys (scales 1:20,000 to 1:125,000) and exploratory surveys (scales 1:125,000 and greater). Surveys which have been entered into the CanSIS computerized system are also indicated. This computerized system is capable of producing derivative maps such as peatland maps of the survey area. More detailed information concerning these surveys can be found in the Index to Soil Surveys (1980). Since 1980, areas in north-central Ontario, the high Arctic islands, the northern Yukon, the Mackenzie Delta, Great Bear Lake, Coppermine and north of Great Slave Lake have been partially surveyed.

NORTHWEST PART OF THE MER BLEUE PEATLAND

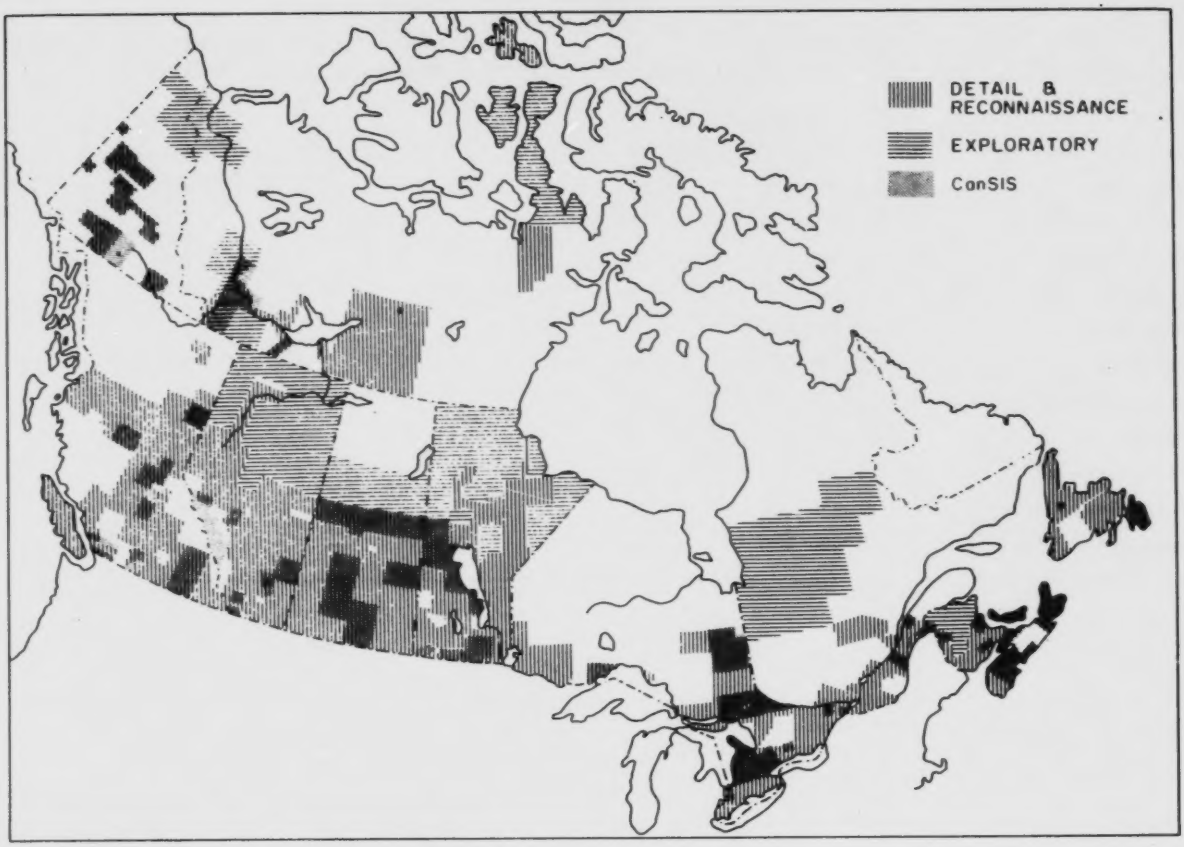


LEGEND

Map Symbol	Peat Landform	Organic Parent Material	Drainage	Soil Association	Soil Taxonomy	Vegetation
H1	Basin Swamp Stream Swamp	Greater than 160 cm of moderately to well decomposed woody forest peat underlain by moderately to well decomposed woody or sedge fen peat.	poor to very poor	Huntley 1	Typic Humisol Mesic Humisol	Mixed maple, birch and aspen (hardwood) or dense cedar forest with an understory of ferns, grasses, mosses and tall shrubs. Stream swamps are usually associated with alder and willows.
H2	Basin Swamp Peat Margin Swamp	40 to 160 cm of moderately to well decomposed woody forest peat or moderately to well decomposed woody forest peat underlain by moderately to well decomposed sedge or moss fen peat.	poor to very poor	Huntley 2	Terric Mesisol Terric Humic Mesisol	Mixed maple, birch and aspen (hardwood) or hardwood - cedar or dense cedar forest with an understory of ferns, mosses, grasses and tall shrubs.
H3	Basin Swamp	40 to 160 cm of moderately to well decomposed woody forest peat or moderately to well decomposed woody forest peat underlain by moderately to well decomposed sedge or moss fen peat.	poor to very poor	Huntley 3	Terric Humisol Terric Mesic Humisol	Mixed maple, birch and aspen (hardwood) or hardwood - cedar or dense cedar forest with an understory of ferns, mosses, grasses and tall shrubs.
M1	Flat Bog Domed Bog Basin Bog	30 to 160 cm of undecomposed sphagnum peat underlain by moderately decomposed fen or forest peat. Mineral contact occurs at a depth greater than 160 cm.	poor	Mer Bleue 1	Typic Mesisol, sphagnic phase Fibric Mesisol, sphagnic phase	Black spruce and tamarack forest with an understory of Sphagnum and feather mosses and Ericaceous shrubs or Ericaceous shrubs and Sphagnum mosses with patches of black spruce and tamarack.
Q1	Horizontal Fen	Greater than 160 cm of moderately to well decomposed fen peat.	poor to very poor	Queenswood 1	Humic Mesisol Mesic Humisol	Sedges and mosses.
Q2	Horizontal Fen	40 to 160 cm of moderately to well decomposed fen peat.	poor to very poor	Queenswood 2	Terric Humisol Terric Mesic Humisol	Sedges, mosses and some shrubs with clumps of tamarack.
MW	Mineral Wetland	Less than 40 cm of moderately to well decomposed peat underlain by fine to medium textured mineral material.	poor to very poor	Mineral Soil	Rego Gleysol, peaty phase Rego Humic Gleysol peaty phase	Mixed aspen, maple and birch or willows.

Figure 3: Peatland inventory of part of the Mer Bleue peatland. Explanation of map symbols is shown in the legend. The cross-section (A to B) is shown in Figure 2. The symbol MT stands for upland mineral terrain.

Figure 4. Areas where soil survey inventories were carried out prior to January 1980.



The estimated areal coverage of peatlands (areas having peat depths greater than 40 cm) in Canada and in the provinces and territories, is presented in Table 2. These figures are derived from the CanSIS computerized data bank and are based on the distribution of soils in Canada. According to this estimate, the total area of peatlands in Canada is 107 986 400 ha, representing 12% of the land area or 11% of the total area (land and water) of Canada. When the various provinces and territories are compared, the Northwest Territories has the largest area of peatlands (25 111 100 ha) followed by Ontario (22 555 100 ha) and Manitoba (20 664 200 ha). The largest concentration of peatlands is found in Manitoba (38% of the land area and 32% of the total area), followed by Ontario (25% of the land area and 21% of the total area). Almost one-quarter (23%) of the total Canadian peatlands are found in the Northwest Territories, followed by Ontario (21%) and Manitoba (19%). Approximately 60% of the total Canadian peatlands are perennially frozen.

It should be realized, however, that these figures are only estimates since a large part of the area of Canada, especially in the north and along the Pacific Coast, has only been partially surveyed.

GAPS IN PEATLAND INVENTORIES AND DATA

Information generated by peatland inventories provides reliable areal information about the peatlands. The level of information concerning

Table 2: The area and percentage distribution of peatlands in Canada and the various provinces and territories (derived from the CanSIS computerized data bank).

Region	Peatland area (ha)	% of peatland within various regions based on		% of total Canadian peatlands within various regions
		Land area	Total area (land & water)	
Alberta	12 672 900	20	19	12
British Columbia	1 289 500	1	1	1
Manitoba	20 664 200	38	32	19
New Brunswick	803 700	11	11	*
Newfoundland	2 429 300	6	6	2
Northwest Territories	25 111 100	8	7	23
Nova Scotia	137 000	2	2	*
Ontario	22 555 100	25	21	21
Prince Edward Island	3 000	*	*	*
Quebec	11 712 700	9	9	11
Saskatchewan	9 309 500	16	14	9
Yukon Territory	1 298 400	3	3	1
Canada	107 986 400	12	11	

*Less than 1%

such factors as peatland types and characteristics and depth of the peat deposit varies. This information, however, is very much needed when evaluating the peat resource for energy and other land use and, thus, future peatland inventories should concentrate on collecting this data.

Additional work must be carried out both in areas where land use conflicts relating to peatlands are developing and in areas where peat deposits are most likely to be utilized for energy. We feel that one of these areas is the St. Lawrence Lowlands.

Studies of peatlands are also very much needed in areas where deep peat deposits are common but for which a very limited number of surveys are available. One of these areas is the Pacific Coast peatlands on the British Columbia mainland and on Vancouver Island and the Queen Charlotte Islands.

Information concerning the extent of peatlands both in the provinces and for Canada as a whole varies quite widely. Table 3 notes the areas of peatlands (within the provinces and in Canada) estimated by various sources. The disparity in the figures indicates that this information is based mainly on inference, rather than on actual resource inventories. There are large areas of Canada for which no resource inventories have been carried out to date. These areas occur mainly in the northern parts of the provinces and in both of the territories. In order to evaluate the peatland potential of Canada, future inventories should concentrate on these areas.

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Table 3: Area of Canada's peatlands (from various sources).

Region	Area of Peatland (ha) Reported by Various Sources							
	Soil Survey	Tibbetts 1980	Kivinen and Pakarinen 1980	Monenco Ontario Ltd. 1981	Smith 1975	Wells and Pollett 1980	Muskeg Subcommittee of NRC 1977	Zoltai 1979
Alberta	12 672 900	10 000 000						
British Columbia	1 289 500	970 000						
Manitoba	20 664 200	5 500 000			19 341 000			
New Brunswick	803 700	100 000						
Newfoundland	2 429 300	2 000 000				2 000 000		
Northwest Territories	25 111 100	not available						
Nova Scotia	137 000	10 000						
Ontario	22 555 100	16 000 000		26 000 000				
Prince Edward Island	3 000	2 000						
Quebec	11 712 700	12 000 000						
Saskatchewan	9 309 500	4 000 000						
Yukon Territory	1 298 400	not available						
Canada	107 986 400		170 000 000				129 500 000	153 000 000

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MAPPING OF PEAT DEPOSITS IN GEOLOGICAL SURVEYS

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ABSTRACT

The Geological Survey of Canada has not systematically collected data on peat because, until recently, there was little demand for peat information. Some surficial geology mappers have gathered detailed information in specific surveys.

RÉSUMÉ

La Commission géologique du Canada n'a pas systématiquement recueilli de données sur la tourbe parce que, jusqu'à tout dernièrement, ces renseignements n'étaient pas beaucoup en demande. Certains cartographes de la géologie superficielle ont rassemblé des renseignements détaillés au cours de relevés particuliers.

INTRODUCTION

Peat has not been treated in a consistent manner in surficial geology studies conducted by the Geological Survey of Canada. Often it is viewed in much the same manner as forest -- that is as a nuisance which hides the geology. Where it is treated as a map unit generally a single subdivision is used -- organic deposits -- and this is described as: bog, fen, swamp and marsh containing peat, muck and marl. About the only time we probe organic deposits is to find out what is underneath them and we only sample them when we want to collect material for constructing pollen profiles. It is not that geologists don't appreciate the value of peat but until recently there did not seem to be any demand for peat information.

Possibly the first place where "organic deposits" were taken seriously by surficial geology mappers of the Geological Survey, was during the course of the Mackenzie Valley work in the early 1970's. One main reason for conducting the Mackenzie Valley studies was to assess the potential impact of terrain disturbances. It was soon realized that different ground temperature states (frozen or unfrozen) were reflected by the type of organic deposits present. Consequently areas of organic deposits were classified as being either bogs or fens (Hughes *et al.* 1973, Rutter *et al.* 1980). Some field time was devoted to determining the state and ice content of the peat but in general the mapping was an airphoto interpretation exercise.

CURRENT SITUATION

The Geological Survey of Canada is still not treating peat in the same way as other surficial materials. In some cases, subdivisions based on morphology are made (Dredge and Nixon 1981) but thickness and materials information is not gathered on a systematic basis. There are several people in the Geological Survey who argue that peat should be treated as vegetation and because vegetation is not shown on our maps, peat should be ignored also. Fortunately these people are in the minority. Even so, there is a tendency to only map organic deposits where there is uncertainty about the nature of the mineral substrate. One way that has been found to get around this concern of having peat units dilute the geology, has been to show the presence of organic materials by using an overlay pattern on the surficial materials map units (Klassen and Netterville 1980, Fulton *et al.* 1981). This method does not provide any information concerning the nature of the organic material present but it does alert the reader to the areal extent of wetlands.

Provincial geological surveys in Canada in general have not treated peat in anymore of an enlightened way than we have. This may however be changing if what is happening in Ontario is an indication of what the other geological surveys will be doing in the future.

The Ontario Geological Survey Peatland Inventory Program is discussed elsewhere in these proceedings.

I am not familiar with how geological surveys in other countries are tied in with peat resource inventories and exploitations. I understand however that in Finland, peat research forms a major segment of the geological survey program. In Finland, regional peat reserves were assessed as part of their Quaternary mapping program and now they are engaged in proving out deposits by going as far as calculating the BTU's stored in individual bogs.

I don't feel that peat will be given a particularly high profile in our work in the near future. We undoubtedly will continue to outline wetland areas as we have done in the past. What is required however is a systematic probing and sampling of deposits to determine quality and reserves. This however is work at a level of detail which the Geological Survey of Canada does not have the resources to conduct.

Something else that must be considered in gearing up for a peat inventory program in Canada is that peat is a resource and the provinces control our natural resources. CANMET of the Department of Energy, Mines and Resources, financed several peat research projects on contract. One of these was a Canada-wide inventory of peat-fuel resources and others were related to a demonstration project relating to generating electricity from peat. In the demonstration project, a source of fuel peat was proved out, bog exploitation plans were developed and a rough design drawn up for a thermal power plant. However, Energy, Mines and Resources could take the work no further. The local provincial power company controls electricity generation and distribution so that no one else could pick up the exploitation of this resource. The provincial power company was not interested in power generation from peat and consequently the project died. Hence it appears to be futile for the Federal Government to become deeply involved in peat inventory programs if the provinces do not have a real interest in following up with exploitation.

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PEATLAND INVENTORIES FOR NEWFOUNDLAND: METHODOLOGY AND APPLICATION

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ABSTRACT

The Island portion of the province of Newfoundland and Labrador is presently being inventoried for peatland deposits. Up to 1981, 53,047 deposits have been mapped covering an area of 663 770 ha of peatlands; these figures represent about 50% of the land area of the Island. The total volume of peat is 10.9 billion cubic metres comprising about 49% in each of the fibric and mesic categories; the remaining 2% consist of humic peat. All peat deposits have been classified into bog, fen, marsh, and swamp types in accordance with the National Wetland Classification System (Tarnocai 1980). The data is presently being used for assessment of peat fuel potential and resource planning for the island of Newfoundland.

RÉSUMÉ

Nous avons inventorié jusqu'ici les tourbières de la moitié de la superficie de l'île de Terre-neuve. En 1981, 53,047 tourbières d'une superficie totale de 623 770 ha avaient été répertoriées. Le volume total de tourbe est de 10.9 milliards de mètres cubes, dont 49% appartiennent aux catégories fibrique et mésique, respectivement, tandis que les 2% qui restent sont des tourbes humiques. Toutes les tourbières ont été catégorisées comme tourbières oligotrophes, tourbières minérotrophes, marais ou marécages en conformité avec la classification nationale des terres humides (Tarnocai 1980). Les données disponibles peuvent maintenant servir à la planification des ressources, et servent présentement à l'évaluation du potentiel terre-neuvien en tourbe énergétique.

INTRODUCTION

Peatlands form a large component of the island of Newfoundland; some estimates (Pollett 1972, Pollett and Wells 1980, Wells and Vardy 1980) range from 12-15% of the landscape or in excess of 1 600 000 ha. These peatlands, however, have not contributed significantly to resource development within this Province. Several small sites have been ditched for forestry purposes and a large agricultural research area has been established in eastern Newfoundland. About sixteen sites (approximately 339 ha) have been converted to community pastures throughout the Island but only one site is being used for horticultural purposes. Thirty to forty years ago peatlands were used locally in southeastern Newfoundland as a fuel supplement, but with increasing utilization of oil and natural gas which, until recently was relatively inexpensive, the use of peat for energy has disappeared.

In recent years, however, rapidly increasing oil prices coupled with uncertainties of future oil supplies, as well as the need for more effective land resource management have led to a reassessment of our peatlands for energy or resource needs. Although very little emphasis has been directed toward assessing the potential of peatlands as an alternate source of energy in Newfoundland, a six-year peatland inventory of the Island part of Newfoundland and Labrador was initiated in 1978 by the Newfoundland government and funded under the Federal-Provincial General Development Agreement. The principal objectives of this inventory are to determine the location and area of peatland deposits, to provide estimates of volume for each major peatland type, and to provide data to facilitate the needs of resource planners.

INVENTORY METHODOLOGY

To date, peatland deposits have been inventoried for four regions: Northeastern (1978), Western (1979), Eastern (1980), and Northern (1981) (see Figure 1). In outlining the methodology used, examples have been drawn from the Northland (1980) report on Eastern Newfoundland. Four work phases are identified:

I. Delineation of ecodistricts
II. Aerial photo interpretation and mapping

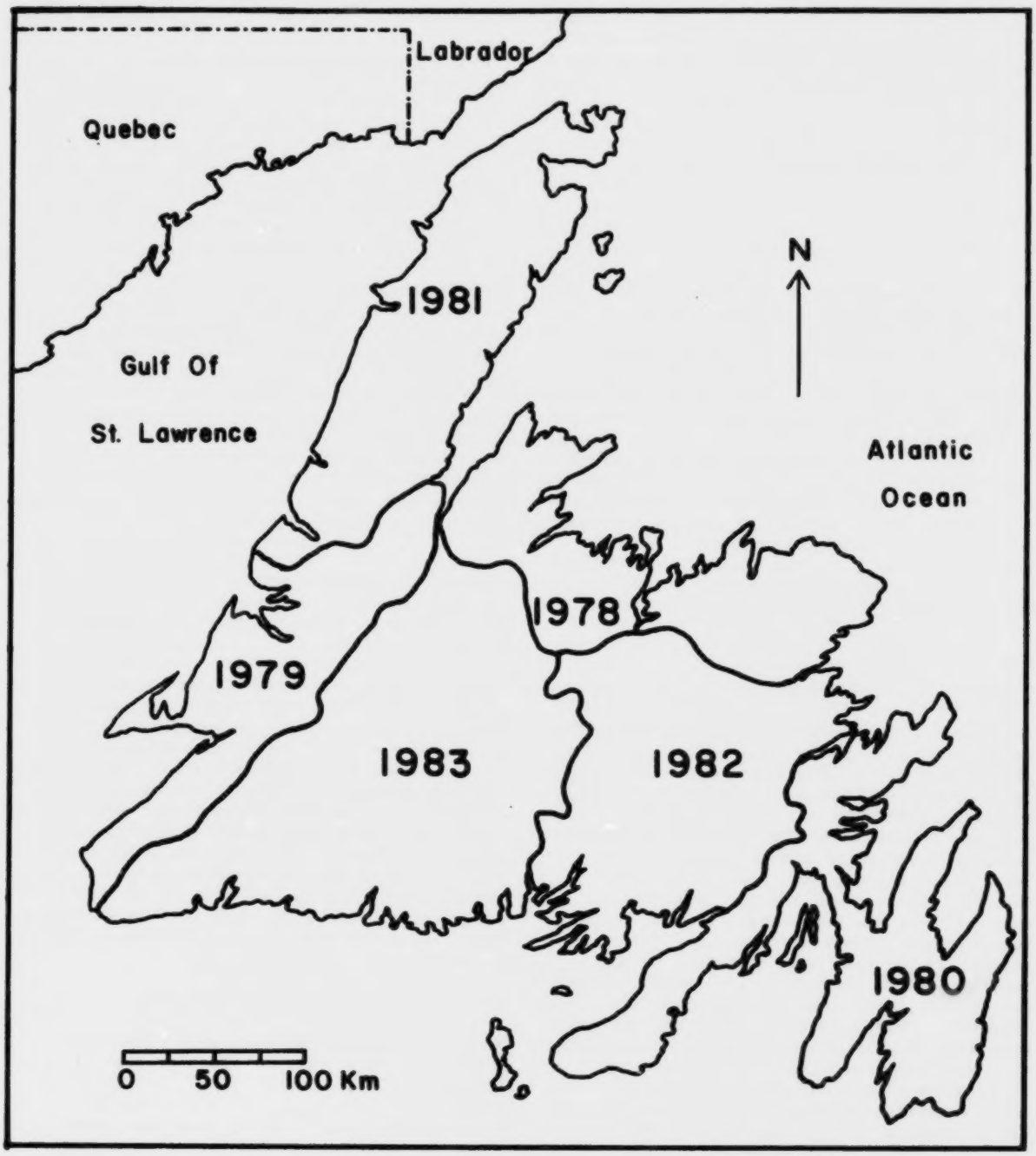


Figure 1: Map of insular Newfoundland showing peatland inventory schedule.

III. Field surveys
IV. Data compilation

I. Delineation of Ecodistricts

In order to derive maximum value from the field sampling program an ecodistrict map was prepared for the entire study area. Ecodistricts are components of an ecoregion, characterized by a distinctive pattern of relief, geological structure, geomorphic evolution and associated vegetational complexes. For the eastern region 20 ecodistricts, numbered 31 to 50[1] were identified. These districts served as a primary stratification of the land surface, and the field-sampling intensity was dictated by the area of peatland within each of the districts.

II. Aerial Photo Interpretation and Mapping

Two distinct, but related tasks were involved in this phase: (a) air photo interpretation, and (b) mapping.

Air photo interpretation - Preliminary air photo interpretation using high level 1:110,000 colour photography and 1:50,000 black and white photographs was undertaken. This provided an overview of the types and distribution of the various wetland deposits within each ecodistrict. Upon completion of the preliminary interpretation, field checks were undertaken to gather additional ground truth data and to confirm the preliminary interpretation.

The second task in the air photo interpretation involved the delineation of the boundaries and classification of the wetland deposits. All deposits greater than 1.0 ha were classified. Interpretation was made using 1:12,500 colour and 1:15,840 black and white photography. This segment of the interpretation along with the overview, provided the basis for the design and planning of the field survey phase.

The classification of wetland types followed the wetland types outlined in the Canadian Wetland Registry as developed by the Wetland Classification System (Tarnocai 1980). For the Eastern study area, the following wetland types were identified.[2]

A. Bogs

1. Basin (BB)
2. Domed (DB)
3. Atlantic Plateau Bog (APLB)
4. Slope (SB)
5. Blanket (BLB)

B. Fens

1. Patterned (PF)
2. Slope (SF)
3. Ladder (LF)

C. Marshes

1. Stream (SM)
2. Lentic (LM)
3. Estuarine (EM)

D. Swamps

1. Stream (SS)

The scale of interpretation did not permit a clear separation of bog and fen components especially where both peatland types formed extensive peatland complexes. These deposits were delineated and classified as complexes. For example, a "Domed Bog-Ladder Fen Complex" would be designated as DB-LF indicating that the domed bog comprised the larger portion of the complex.

The area of each deposit was measured using a conventional dot grid. In addition, designations were assigned to the larger deposits (i.e. bogs > 30 ha and fen > 5 ha). These designations reflected type, drainage and restriction, percentage of open surface water, pool pattern, percent slope and direction. The following system was used:

Type - Wetland Classification System

Drainage Limitation	Pool Patterns
a - low	C - Concentric
b - moderate	E - Eccentric
c - severe	I - Irregular
	P - Parallel

Aspect	Slope
Eight point compass method	Degrees

Water Areas

Percentage of surface

A typical designation for a larger deposit could be:

---

[1] Ecodistricts 1-30 are located in Northeastern and Western Newfoundland, and were surveyed in 1978 and 1979 respectively.

[2] For detailed ecological description of peatland of eastern Newfoundland (see Wells 1981).

1 APLB 110.5 ha c 40% I 2° NE

(Deposit #1, an Atlantic Plateau bog, 110.5 ha in area with severe drainage limitations, 40% surface water with irregular pool patterns, slope is approximately 2% in a northeasterly direction.)

Mapping - Once the interpretation was completed the data was transferred from the photographs to a forest inventory cover type map at a scale of 1:12,500. A base map of the same scale was prepared and all the peatland classification drafted on. The objective was to have on file a complete set of maps for the Island, at a scale of 1:12,500 showing classification, area and location of all wetland deposits greater than 1.0 ha.

III. Field Survey

Field sampling was conducted by two 2-man teams. Ecodistricts were stratified throughout the study area according to the percentage of deposits occurring within each district. Wherever possible, all wetland types occurring within a district were sampled. A helicopter was used to reach inaccessible areas.

Field sample points were located on organic deposits using a variable grid system. The size of the grid varied with the size of the deposit. Sample deposits were outlined on 1:15,840 black and white aerial photographs and the appropriate grid was used to mark the locations of the sampling points. The field crews then used the photographs to accurately locate the sample points.

At each sample station on the established grid, a depth sounding was taken and the following information recorded:

1) Deposit number
2) Grid reference number
3) Depth of stratum (cm)
4) Type of bottom materials
5) General comments

In all, 2074 depth soundings were taken during the Eastern Region study.

Samples were taken along the major axis of the deposit, or where changes in strata occurred, the major strata (more than 0.5 m) were sampled by means of a 1 m Hiller sampler and the following information recorded:

1) Deposit number
2) Grid reference number
3) Depth of stratum (cm)
4) Colour of stratum (Munsell colour notations)
5) von Post scale of humification
6) C.S.S.C. classification
7) Total depth (metres)
8) General comments

During the Eastern Region study, 711 samples were recorded in this manner.

At each of these stations a 250-400 gram sample was collected for each of the major strata (more than 0.5 m in thickness).

These samples were placed in plastic sample bags and labelled as follows:

1) Deposit number
2) Grid reference number
3) Depth of stratum (cm)
4) Stratum thickness (cm)
5) C.S.S.C. classification

During the Eastern Region study 459 samples were collected and deposited with the Canadian Forestry Service for future analytical work.

IV. Data Compilation and Presentation

The volume of fibric (H1-4), mesic (H5-7), and humic (H8-10) peat was calculated from the detailed core measurements by constructing a profile of the depths at each profile type. The proportion of each type was multiplied by the total deposit area to obtain the volume of fibric, mesic and humic material in the deposit. Field checks on peatland deposits inventoried in more detail during earlier horticultural peat surveys (Pollett 1968), determined that the present survey volumes were within 6% of the detailed volume estimates. This data was then presented in a report format. See the following example.

Summary of the Eastern Study Area

All organic deposits within the study area over one hectare in area were mapped and classified and volumes computed for each deposit. These data were summarized and presented as separately bound volume tables. The study area was divided into 20 biophysical ecodistricts and field sampling was dictated by the area of organic deposits occurring within each district. Seven hundred and eleven peat samples were classified by depth, C.S.S.C. group, von Post scale and Munsell colour notation. Four hundred and fifty-nine of these were collected and delivered to the Newfoundland Forest Research Centre. In addition, 2074 depth measurements were made for volume calculations.

In total, there were 17,525 organic deposits mapped within the study area. The total

volume of peat was computed to be 4 122 606 900 m^3. This was composed of 1 328 502 100 m^3 of peat within the von Post range of H1-H4; 2 702 394 800 m^3 within the range of H5-H7, and 91 700 000 m^3 within the range of H8-H10. The 17,525 organic deposits occupied a total area of 273 548 ha or 14.36% of the total land mass within the study area.

The number of organic deposits, the area and the volume of peat occurring within each of the ecodistricts, have been summarized and are presented for each ecodistrict (see following example and Table 1 for ecodistrict 42).

Ecodistrict 42 -
Burin Ecodistrict

Ecodistrict 42 constitutes the greater portion of the Burin Peninsula. The underlying bedrock is primarily acidic to mafic volcanic rocks, with a variety of other types also present. The topography is hilly to rolling with a mean elevation of approximately 140 m. Rock and soil barrens with scrub forest types on sheltered slopes constitute the land/vegetation complex. The land mass of ecodistrict 42 is 364 885 ha.

Organic deposits comprise 78 494 ha of this land mass (21.51%) with a total volume of 1 056 825 000 m^3. This volume is composed of 320 182 000 m^3 of H1-H4, 733 433 100 m^3 of H5-H7, and 3 209 900 m^3 of H8-H10. There were 4,366 deposits mapped in ecodistrict 42.

Table 1 gives a detailed summary of organic deposits in this ecodistrict.

In addition, summaries of peat inventory data were prepared for all ecodistricts (Table 2). All designated deposits, those of sufficient size to be considered as having development potential (bogs, complexes more than 30 ha, fens and marshes more than 5 ha) are listed by 1:50,000 map sheets, and the total number, area, and volumes are shown for each (Table 3).

APPLICATION OF INVENTORY DATA

This paper has presented the methodology and examples of results obtained in the peatland inventory of eastern Newfoundland. Yet, to date, four regions of the Island have been surveyed. As an example of how the inventory data can be applied, the results of the inventory for these four regions are presented below in Table 4. The greatest quantity of fibric peat (peat moss) occurs in the large domed bogs in northeastern Newfoundland. Fuel peat (mesic), on the other hand, is most abundant in the extensive blanket bogs of eastern Newfoundland. Using the available information on location and quantities of peat fuel, area ratings were also prepared (Figure 2). Furthermore, using site specific information, it was also possible to focus on potential locations for industrial development (Figure 3). Similarly, information can be extracted for assessment of other resource uses of peat such as forestry, agriculture, wildlife and conservation.

Table 1: Summary of peat inventory data for eco-district 42.

Organic types	Deposits		Area		Volume (Hundreds of cu.m)					
	Number	%	Hectares	%	von Post H1 - H4	%	von Post H5 - H7	%	von Post H8 - H10	%
SB	3 272	74.96	10 628	13.54	414 492	12.95	1 009 660	13.77	-	-
BLB	855	19.58	63 749	81.22	2 741 207	85.61	6 119 904	83.44	-	-
DB	8	0.18	50	0.06	3 700	0.12	2 100	0.03	-	-
BB	8	0.18	16	0.02	1 072	0.03	1 728	0.02	-	-
SF	5	0.11	9	0.01	90	-	585	0.01	45	0.14
PF	44	1.01	676	0.86	6.760	0.21	43 940	0.60	3 380	10.53
LM	48	1.10	86	0.11	-	-	-	-	3 612	11.25
SM	11	0.25	24	0.03	-	-	-	-	1 008	3.14
Complexes	115	2.63	3 256	4.15	34 499	1.08	156 414	2.13	24 054	74.94
Totals	4 366	100	78 494	100	3 201 820	100	7 334 331	100	32 099	100

Table 2: Summary of peat inventory data of eastern Newfoundland.

Eco-district	Deposits		Area		Volume (Hundreds of cu.m)					
	Number	%	Hectares	%	von Post H1 - H4	%	von Post H5 - H7	%	von Post H8 - H10	%
31	51	0.29	2 383	0.87	18 237	0.14	67 314	0.25	1 012	0.11
32	1 061	6.05	17 237	6.30	416 849	3.14	1 665 345	6.16	99 600	10.86
33	1 542	8.80	17 061	6.24	1 025 903	7.72	1 479 403	5.47	49 971	5.45
34	310	1.77	3 285	1.20	393 289	2.96	228 537	0.85	7 992	0.87
35	132	0.75	817	0.30	20 397	0.15	122 782	0.46	1 678	0.18
36	4 273	24.38	42 407	15.50	3 355 955	25.26	4 561 431	16.88	258 879	28.23
37	1 214	6.93	15 319	5.60	1 244 096	9.36	2 372 632	8.78	44 846	4.89
38	310	1.77	16 839	6.16	761 913	5.74	1 773 584	6.56	146 444	15.97
39	317	1.81	1 313	0.48	16 325	0.12	200 710	0.74	17	-
40	389	2.22	2 234	0.82	80 131	0.60	184 007	0.68	35 097	3.83
41	352	2.01	671	0.25	31 551	0.24	68 654	0.25	2 830	0.31
42	4 366	24.91	78 494	28.69	3 201 820	24.11	7 334 331	27.14	32 099	3.50
43	630	3.59	8 782	3.20	312 716	2.35	390 186	1.44	15 102	1.65
44	215	1.23	10 382	3.80	172 778	1.30	632 381	2.34	22 268	2.43
45	743	4.24	13 757	5.03	455 656	3.43	2 642 927	9.78	35 683	3.89
46	11	0.06	36	0.01	1 675	0.01	3 436	0.01	262	0.03
47	802	4.58	8 810	3.22	696 568	5.24	830 948	3.07	52 412	5.71
48	555	3.17	30 999	11.33	940 424	7.08	2 208 727	8.19	89 974	9.81
49	102	0.58	479	0.18	26 373	0.20	46 592	0.17	2 419	0.26
50	150	0.86	2 243	0.82	112 365	0.85	210 021	0.78	18 515	2.02
Totals	17 525	100	273 548	100	13 285 021	100	27 023 948	100	917 100	100

Table 3: Sample summary table of designated deposits by 1:50,000 map sheets.

Map sheet	Type	No.	Area in hectares	Volume (Hundreds of cu.m) von Post H1 - H4	von Post H5 - H7	von Post H8 - H10
Sunnyside	SB	22	2 608	60 437	281 166	15 378
	Complexes	2	1 072	55 724	96 444	13 930
Tug Pond	SB	20	1 929	53 759	210 458	7 873
	DB	4	213	39 209	6 926	-
	SF	21	179	1 969	10 919	358
	PF	37	15 736	173 096	959 896	31 472
	SS	3	24	-	48	864
	Complexes	38	13 069	436 174	894 079	33 606
Random Island	SB	6	736	35 241	78 731	2 302
	DB	1	31	4 557	2 418	62
	Complexes	8	1 330	131 702	139 365	11 480
Port Blandford	SB	16	1 163	42 053	127 388	1 026
	DB	1	59	8 644	4 586	118
	SF	9	73	803	4 453	146
	PF	1	262	2 882	15 982	524
	SS	2	16	-	32	576
	Complexes	46	4 672	302 719	578 865	57 090
Sweet Bay	SB	8	335	16 425	35 866	1 006
	DB	12	786	115 586	61 331	1 573
	SF	8	74	814	4 514	148
	SS	7	76	-	152	2 743
	LM	1	6	-	12	216
	Complexes	28	1 218	116 889	116 759	9 932
Trinity	SB	10	470	34 870	49 949	3 597
	DB	2	83	18 359	91 797	-
	LM	1	12	-	24	432
	SM	1	9	-	18	324
	Complexes	5	636	97 279	55 951	6 358
Eastport	-	-	-	-	-	-

Table 4: Summary of peat deposits, areas, and volumes for four regions inventoried in Newfoundland.

	Northeastern (1978)	Western (1979)	Eastern (1980)	Northern (1981)	Total
Deposits	19,577	6,407	17,525	9,538	53,047
Hectares	135 493	87 885	273 548	126 844	623 770
Volume in Cubic Metres					
Fibric	2 166 642 180	962 719 160	1 328 502 100	804 941 600	5 262 805 040
Mesic	978 105 960	795 637 380	2 702 394 800	862 914 400	5 339 052 540
Humic	11 715 000	1 023 040	91 710 000	207 350 600	311 798 640

The total volume of peat estimated to date is 10.9 billion m^3.

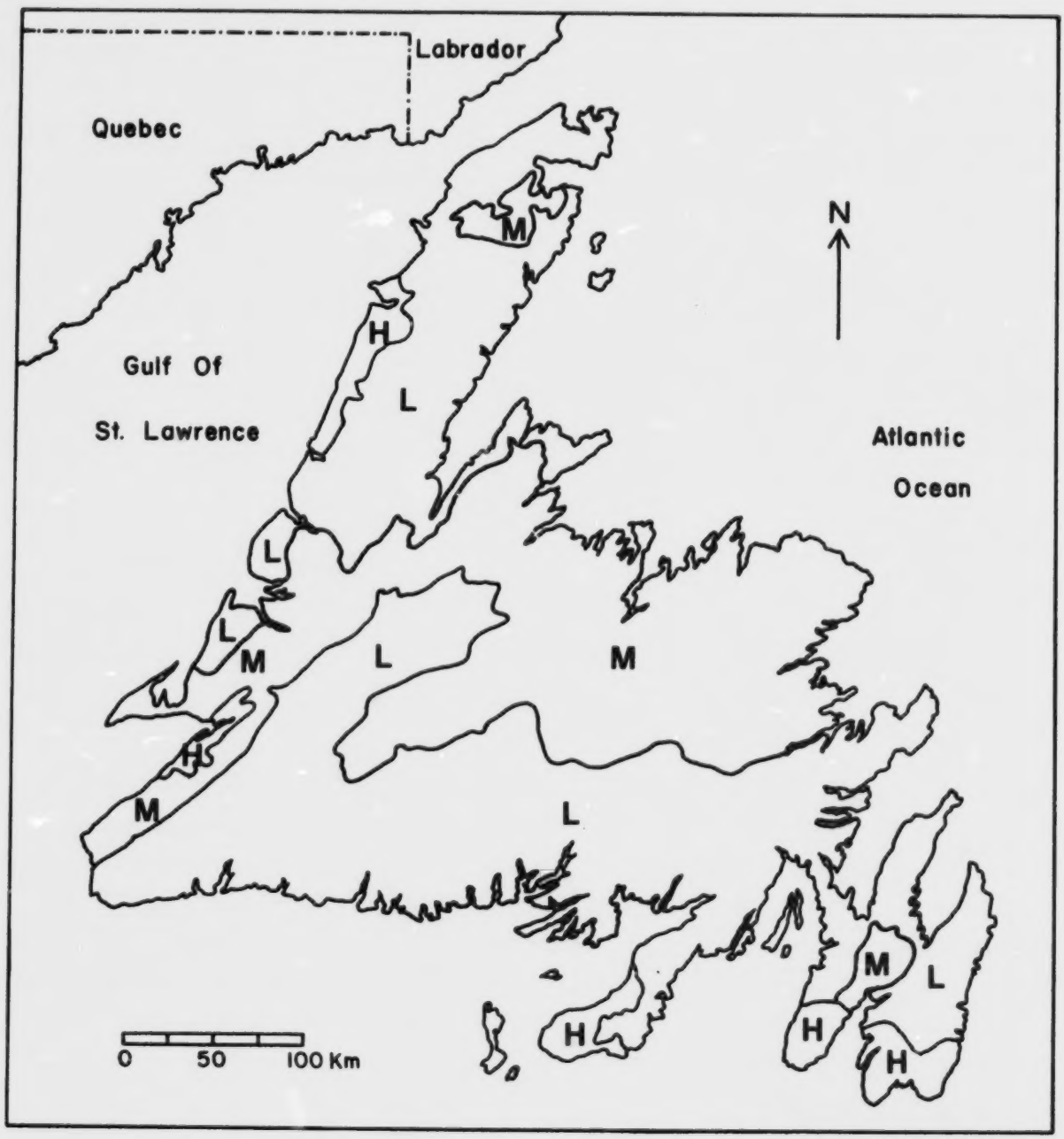


Figure 2. Areas of fuel peat reserves in Newfoundland: high (H), medium (M), low (L) (after Wells and Vardy 1981).

Figure 3: Major fuel peat concentrations and energy potential (after Wells and Vardy 1981).

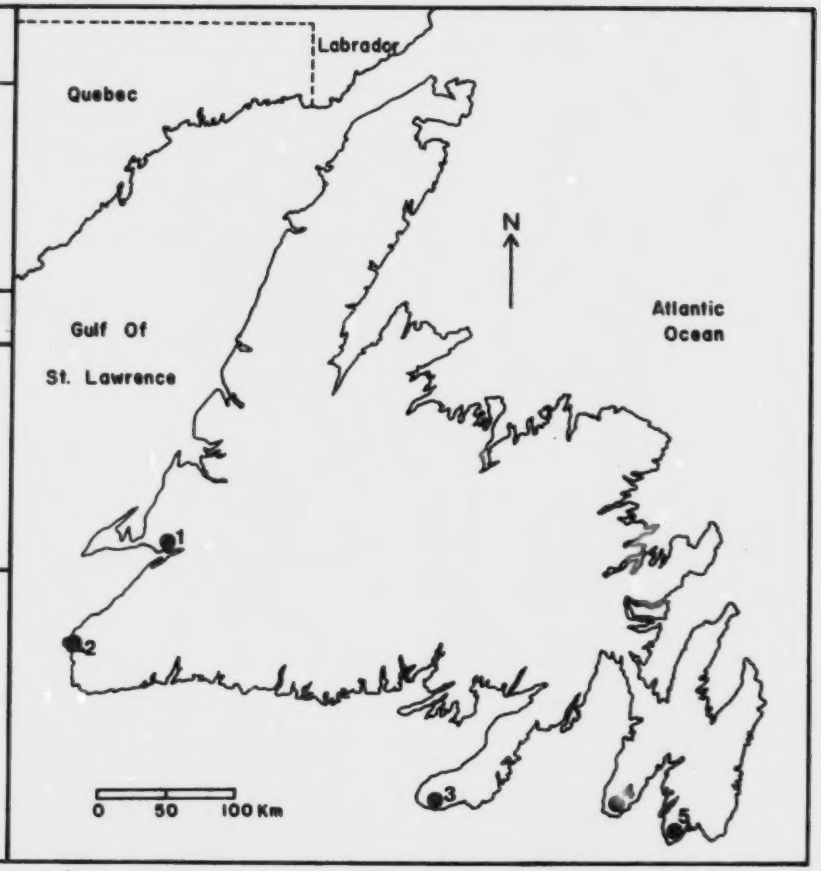
Location	Peat fuel reserves (m^3)	Barrels oil equivalent*	Millions KWH annually	Plant life
1. Stephenville	72 770 100	26 200 000	406	25
2. Codroy	45 418 500	16 350 000	252	25
3. Lamaline**	75 000 000	27 000 000	420	25
4. Branch**	75 000 000	27 000 000	420	25
5. St. Shotts**	75 000 000	27 000 000	420	25
Total	343 188 600	123 550 000	1 918	

Total peat reserves in all five locations = 123 550 000 (barrels oil equivalent)

Total energy consumption in Newfoundland, 1979 = 18 250 000 (barrels oil equivalent)

Conversion factors for peat (m^3) in situ to barrels oil equivalent = 0.36 (based on figures from Montreal Engineering study of peat bogs in northeast New Brunswick; and, "Energy From Peat in Finland" published by VTT, Technical Research Center of Finland) (See Figure 4).

**Preliminary estimates; peatland survey not completed. (Figure courtesy of Northland Associates Ltd., St. John's, Nfld.)



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PEATLAND INVENTORIES IN MANITOBA

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ABSTRACT

This paper summarizes the extent and nature of peatland inventories carried out to the present time in Manitoba. Information concerning Manitoba peatlands varies widely, greater detail being derived from systematic reconnaissance soil surveys and ecological land surveys and less detail from exploratory soil surveys and surficial geology maps.

Manitoba peatlands, estimated to cover 20 600 000 ha, comprise 38% of the Provincial land area and 19% of the total area of peatlands in Canada. Evaluation of Manitoba peatlands is not complete because extensive areas in northern Manitoba are not mapped by systematic reconnaissance survey. In order to complete an initial evaluation of Manitoba's peatland resource, future reconnaissance surveys should concentrate in the north. In addition, detailed inventory information is required for selected peatland areas in the south having potential for development for agriculture or other uses.

Experience indicates that utilizing peat landform as a key element in the mapping process enhances the accuracy, efficiency and economy of peatland inventories. Incorporation of soil and vegetation elements associated with peat landforms into map unit descriptions provides baseline data most useful for interpretation for biologically oriented fields such as agriculture, forestry or wildlife habitat characterization. This data can also be interpreted for a wide range of engineering uses including trafficability studies and prediction of subsurface condition. This methodology portrays as fully as mapping scale permits a maximum amount of information regarding the peatland environment.

RÉSUMÉ

Cet ouvrage résume l'importance et la nature des inventaires de tourbières effectués jusqu'à maintenant au Manitoba. Les informations concernant les tourbières manitobaines varient considérablement, les données plus détaillées découlant généralement des prospections pédologiques de reconnaissance systématique et des levés écologiques, et les données moins détaillées provenant surtout des prospections pédologiques exploratoires et des cartes géologiques superficielles.

Les tourbières du Manitoba comptent environ 20 600 000 ha, soit 38% du territoire provincial et 19% de la superficie totale des tourbières au Canada. L'évaluation des tourbières manitobaines n'est pas complète du fait que de grandes régions situées au nord de la province ne sont pas encore cartographiées par prospection systématique de reconnaissance. Pour compléter une évaluation initiale des ressources en tourbe du Manitoba, d'autres prospections de reconnaissance devraient se concentrer dans le nord. En outre, les informations détaillées tirées d'inventaires sont nécessaires pour certaines régions de tourbières du sud affichant des possibilités d'aménagement pour l'agriculture ou d'autres usages.

Il est prouvé que l'utilisation du relief des tourbières comme un élément clé dans le processus de cartographie améliore la précision, l'efficacité et l'économie des inventaires des tourbières. L'inclusion d'éléments pédologiques et floristiques associés aux reliefs des tourbières dans les descriptions des unités cartographiques fournissent des données de base des plus utiles pour l'interprétation des ressources à vocation biologique comme l'agriculture, la foresterie ou l'aménagement de la faune. Ces données peuvent également être interprétées pour une grande variété d'utilisations techniques incluant des études de praticabilité et de prédiction de l'état subsuperficiel du terrain. Cette méthodologie révèle aussi pleinement que peut le permettre l'échelle cartographique un maximum d'information concernant l'environnement des tourbières.

INTRODUCTION

The Wetland Working Group of the Canada Committee on Ecological Land Classification (CCELC 1981) defines wetland as "land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophylic vegetation and various kinds of biological activity which are adapted to a wet environment". Wetlands include peatlands characterized by more than 40 cm of peat accumulation on which organic soils develop. Also included are peatlands found in colder climatic regions (northern portions of the Boreal and throughout Subarctic and Arctic regions) where the organic material is underlain by permafrost and Organic-Cryosol soils develop.

This paper presents a brief outline of peatland inventories carried out to the present time in Manitoba. Inventory methodology and the kind of information generated by different approaches to mapping are examined and current inventory techniques are described in detail. The extent and nature of inventories completed or in progress in Manitoba are described and areas are identified where basic peat resource data is lacking.

PREVIOUS WORK

Early surveys by Anrep (1912), Hanel (1924), Leverin (1946) and Cameron (1951) reported the composition of some accessible bog areas in Manitoba. Ritchie (1962) described the peatlands of northern Manitoba in terms of dominant plant groupings. This study described regional vegetational patterns and considered the peatland environment from known ecological aspects. Bannatyne (1964) in a survey of southeastern Manitoba used floristic dominants to delimit five vegetation classes indicative of the formation of different kinds of peat. Reader and Stewart (1972) classified four peatland types in southeastern Manitoba according to production-accumulation processes.

The Canada-Manitoba Soil Survey has mapped most of southern Manitoba indicating areas of organic soil, particularly in southeastern Manitoba (Smith and Ehrlich 1964, 1967). Recent reports contain more detailed classification of the organic soils in the Red Rose Washow Bay area (Smith *et al.* 1975) and in the Roseau River area (Mills *et al.* 1977). The soil survey also carried out exploratory soil and terrain surveys from which estimates were derived for the extent of peatlands in northern Manitoba (Ehrlich 1963).

The Geological Survey of Canada (Klassen *et al.* 1971 to 1974 and Dredge *et al.* 1977 to 1978) indicates the areal extent and genetic origin of peatlands as part of their surficial mapping program. Surficial mapping of extensive areas of northern Manitoba have been completed at a broad reconnaissance scale.

INVENTORY METHODOLOGY

Soil Survey Field Studies Prior to 1959

Early soil surveys prior to 1959 indicated the location of peatlands in each project area and described the organic soils in terms of depth, approximate degree of decomposition, nature of the underlying mineral soil and vegetation characteristics as related to dominant peat formers. The soil map of these peatland areas delineated only two separations based on depth. Shallow organic deposits were described as Half Bog soils (30 to 75 cm or 12 to 30 inches thick) and Shallow Peat soils (30 to 90 cm or 12 to 36 inches thick). Deeper organic deposits were described as Bog soils (in excess of 75 cm or 30 inches thick) and Deep Peat soils (peat deposits thicker than 90 cm or 36 inches).

Soil Survey Field Studies, 1959 to 1963

Soil surveys of southeastern Manitoba in the 1960's included extensive areas of peatland which were described in terms of the ecological relationships observed in organic terrain. Although not delineated on the soil map, three major ecological conditions were described as part of an organic soil complex. The organic soils were separated into Shallow and Deep Peat complexes on the soil map. Annotated air photos were included in the report to assist in identifying the ecologically significant conditions within the two depth separations. Poorly drained sites (DP_1, SP_1) support relatively productive stands of black spruce and tamarack occurring on moderately well decomposed woody peat derived from mixed feathermoss and sphagnum. Other soils of the complex are characterized by slightly poorer drainage and support stunted tamarack and black spruce on sites where the main peat former is Sphagnum moss (DP_2, SP_2). The third ecological condition (DP_3, SP_3) consisted of very poorly drained treeless fen and patterned fens in which the dominant peat former is Carex spp. resulting in moderately well decomposed herbaceous and sedge peat (Figure 1).

Soil Survey Field Studies, 1963 to 1972

More recent soil surveys published in the 1970's and early 1980's related the ecological conditions in peatlands to soil type by means of peat materials (Soil Report No. 16 and 21, Mills and Smith 1971, 1981 and Report No. 19, Smith *et al.* 1975). Three major kinds of peat

Figure 1: Detailed map of a portion of the Deep Peat Soil Complex as mapped in the South-Eastern Map Sheet Area (Smith and Ehrlich 1964). DP_1 = Productive black spruce-tamarack site, main peat formers are Sphagnum and feather mosses; DP_2 = Stunted tamarack-black spruce site, main peat former is Sphagnum moss; DP_3 = Treeless, patterned fen-like area having alternate, more or less parallel, mossy ridges and sedge-filled swales; S = Sandilands Series, an upland site. Slope is toward lower right.

materials commonly occur in the Boreal region of Manitoba. These materials influence ecological conditions at the soil surface and physical and chemical properties of the subsoil. Because the peat materials are of vegetal origin, their preserved state as peat reflects the succession of vegetation as characterized by layers differing not only in degree of decomposition but also in the nature of the plant materials.

1. Sphagnum peat forms on poorly and very poorly drained sites which are isolated from nutrient rich ground waters and thus moisture is supplied only by rain. The vegetation occurring on these sites is that of the Sphagnum-black spruce-Ledum or Sphagnum-Ledum communities. The dominant peat formers are Sphagnum mosses with minor amounts of feathermosses and ericaceous shrubs. This material may contain some inclusions of spruce or tamarack wood. Sphagnum peat is relatively undecomposed and usually extremely to slightly acid.

2. Forest peat forms under poorly drained conditions under the influence of nutrient rich ground water. The vegetation occurring on these sites is productive stands of black spruce (black spruce-feathermoss, black spruce-Ledum-feathermoss communities) or less productive black spruce-tamarack-Carex-feathermoss or tamarack-Carex communities. The dominant peat former is feathermoss with some Sphagnum sp. and varying amounts of ericaceous shrubs, woody species and sedges. The forest peat is moderately decomposed and usually medium to slightly acid.

3. Fen peat forms on very poorly drained sites which are also influenced by nutrient rich ground water. The vegetation occurring on these sites is characteristic of Carex-Drepanocladus, Carex-Drepanocladus-Betula and Carex-Drepanocladus-Salix communities. The dominant peat formers are sedges with minor amounts of mosses, reeds, grasses and shrubs. Fen peat is moderately well decomposed and usually medium acid to neutral.

The relationship of vegetation type to associated peat materials across a typical peatland in the central Boreal region of Manitoba is shown schematically in Figure 2.

Soil Surveys, 1972 to Present

The current approach to mapping organic soils in Manitoba describes and maps soil distribution in relation to other features of the environment such as landform, parent material and vegetation. The approach portrays as completely as map scale permits, a maximum amount of information regarding the morphological, chemical and physical properties of organic soils together with other attributes of the landscape.

This approach to mapping emerged in the late 1960's with the recognition of significant ecological relationships between three essential elements or components that exist in the peatland environment: landform, vegetation and soil (Zoltai *et al.* 1968). These mapping techniques were first applied on a large scale in the study of the Organic Soils of the Roseau River Watershed in Manitoba in 1972 and 1973 (Mills *et al.* 1977). Organic soil mapping in this study relied heavily on landform as a

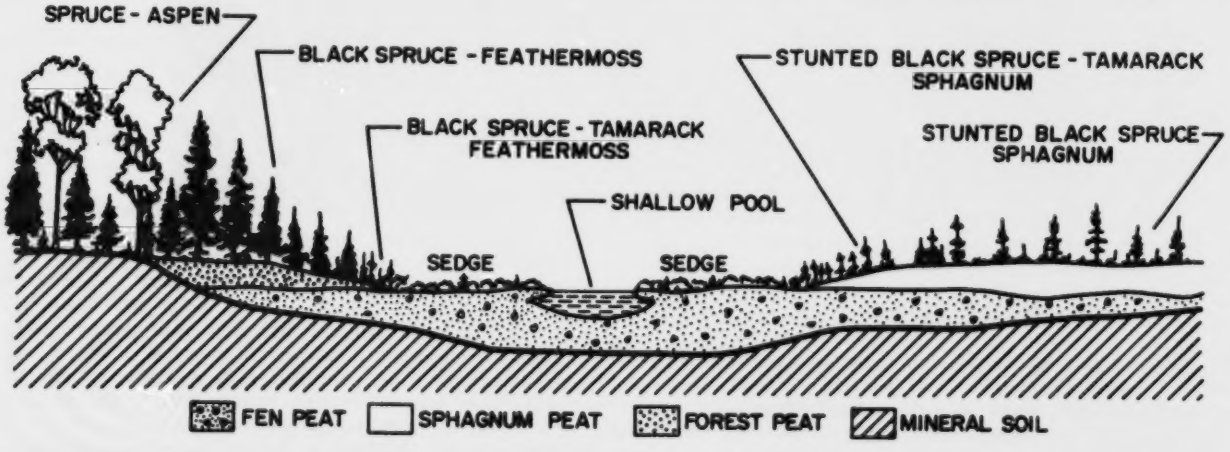


Figure 2. Schematic cross-section of a peatland in the Central Boreal Region of Manitoba (Smith *et al.* 1975).

key element because of the ecological relationships that exist between landform, vegetation and soil. The relationships among these three components depend on interaction of such environmental factors as climate, topographic position, relief, drainage and nutrient status of the ground waters to produce typical vegetation types and subsequently organic landforms and soils. The soil map of the Sprague Peatland is presented in Figure 3 as an example of the mapping methodology used in the Roseau River watershed. An explanation of the map symbol is included in Figure 4 and an example of the organic soil legend is shown in Table 1.

The range of environmental conditions encountered in the Sprague peatland are described in terms of 11 organic landforms, 10 vegetation types, and 15 organic soil types. The kind and distribution of organic landforms vary with climatic conditions, moisture regime, nutrient status of the ground-water and associated vegetation. The landform classification used in the Roseau River study evolved from the work of Adams and Zoltai (1969) and Tarnocai (1970, 1974). The organic landforms utilized for mapping the Roseau River Watershed are indicated in Figure 4.

A wide range of vegetation types occur in the Sprague peatland, varying with position in the peatland, nature of the chemistry of the surface waters, drainage pattern and depth and kind of organic soil. This range of vegetation has been divided into the types listed in Figure 4.

The different organic soil types found in the Sprague peatland relate chiefly to the interrelationships of organic peat materials within an arbitrarily selected control section, their depth and degree of decomposition and the texture of the underlying mineral materials. Sixteen soil series are recognized in the Sprague peatland. The soils of this peatland have developed from five main peat materials defined according to botanical origin and associated physical and chemical properties: i.e. Sphagnum, Forest, Forest-fen, Fen and Aquatic. The distribution of the organic soils in the peatland is shown in Figure 3. The vertical sequence of the peat materials along section C-C^{1} across the peatland is shown in Figure 5.

The mapping methodology illustrated in Figures 3 to 5 and in Table 1 identifies the landform, soil and vegetation elements of each mapping unit by separate parts of the map symbol. Incorporation of the landform and the associated soil vegetation descriptions into map unit descriptions greatly enhances the possibilities and usefulness of interpretations for biologically oriented fields such as agriculture, forestry and wildlife habitat characterization. Identification of a landform type together with knowledge of its properties is very useful for engineering interpretations, trafficability studies and prediction of subsurface conditions. The close relationship between landform and peat material enhances such interpretations.

Remote Sensing Techniques

Most peatland inventories used some form of remote sensing as an aid to classifying and mapping organic terrain. Peatland inventories completed in Manitoba to the present time have relied heavily on the interpretation of conventional panchromatic black and white air photographs. Analysis of photo pattern on such imagery keys on the interpretation of landform, vegetation and drainage pattern in a peatland. Differential reflection of energy from various vegetation types in a peatland create the image that is recorded by a sensor. Most remote sensing techniques in use at an operational level in Manitoba employ sensors in the visible light range. The application of other sensor systems for mapping organic terrain has been researched by several workers.

Examination of early LANDSAT-1 (ERTS) images in 1972 indicated different types of organic soils could be distinguished using remote sensing methods. Although bog areas could be differentiated from fens and marshes, manipulation of these early satellite images by various procedures did not give data with sufficient precision for establishing an operational technique (Bannatyne 1980).

A comparative evaluation of multispectral photographic techniques for the interpretation of peatland forms and associated peatland conditions was made by Tarnocai (1972). Results from this study indicated that colour infrared film being sensitive to variation in reflected energy from different types of vegetation showed potential for mapping organic terrain. The Sphagnum-Carex association in particular has a distinctive prominent signature which can be differentiated readily from other vegetative associations.

Evaluation of the practical usefulness of remote sensing techniques for ecologically based terrain inventories was carried out in subarctic and northern boreal regions of Manitoba (Thie 1976). Although conventional photo-interpretation of aerial photographs was shown to be the most efficient and practical method, the peatland component of the study area was

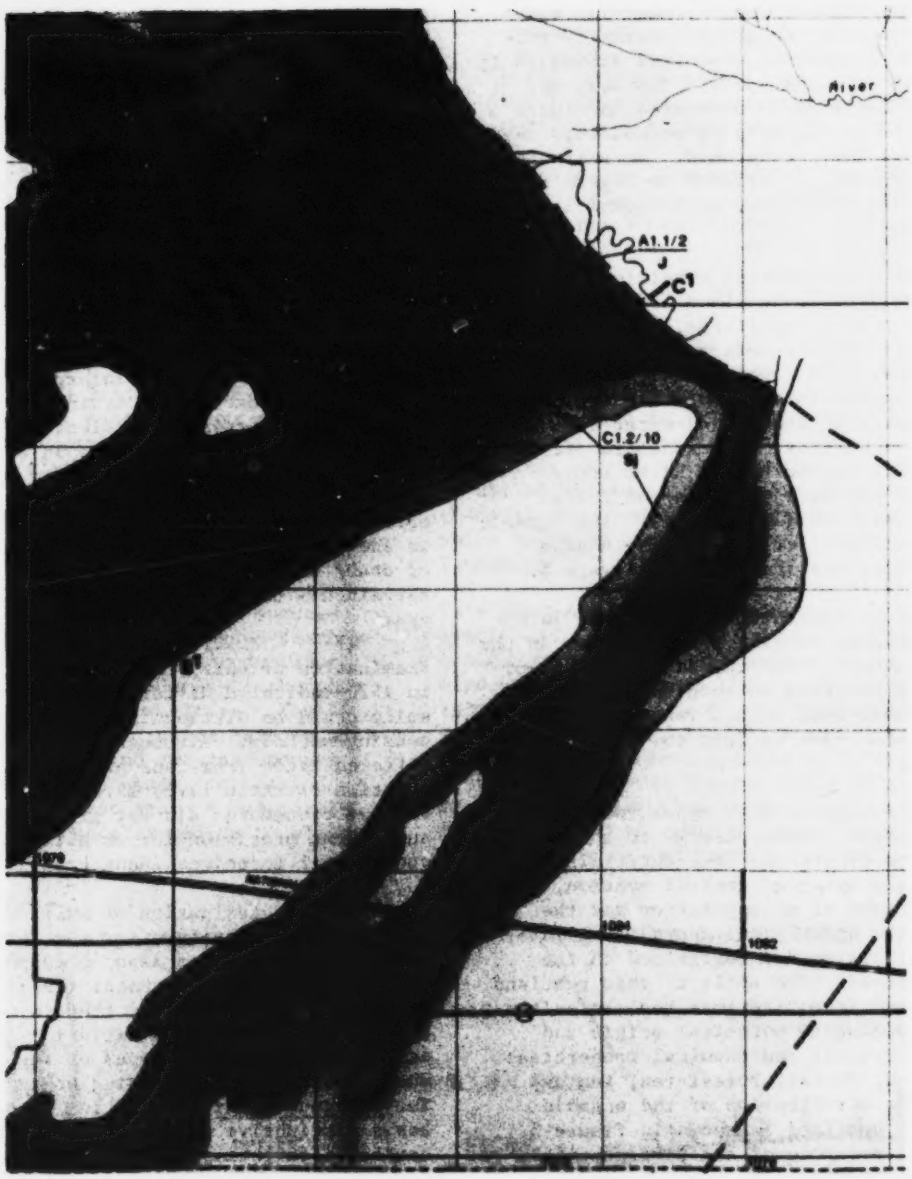
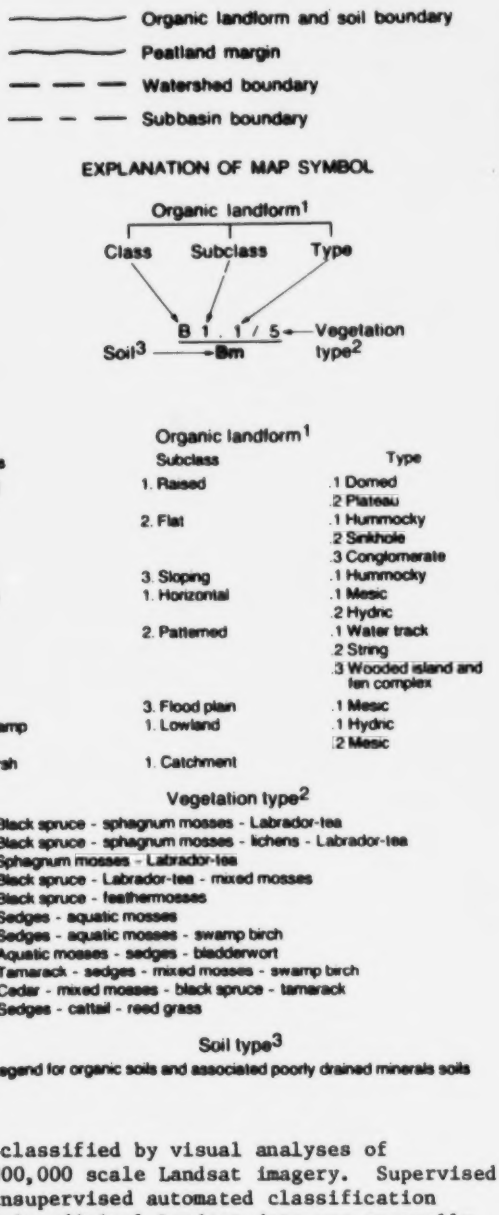


Figure 3: Soil map of portion of the Sprague Peatland in the Roseau River Watershed, southeastern Manitoba map scale: 1:63,360 (Mills *et al.* 1977).

Figure 4: Explanation of map symbol used in the Roseau River Watershed map area, Manitoba (Mills *et al.* 1977).



well classified by visual analyses of 1:1,000,000 scale Landsat imagery. Supervised and unsupervised automated classification utilizing digital Landsat data was generally inferior to results derived from visual methods.

Fraser (1981) evaluated automated classification techniques utilizing Landsat data for soil mapping in the Grand Rapids area of central Manitoba. Automated analysis of the digital Landsat data permitted delineation of patterns of mineral and organic soils in somewhat less detail and accuracy than was obtained by aerial photointerpretation of the same area. Misclassification of organic soils occurred most frequently in areas with similar vegetative cover but different depth of peat materials. The technique did not consistently recognize the depth classes of organic materials required for a quantitative estimate of peat volume.

Thermal infrared imagery has been used to measure energy emitted by various types of vegetation (Bannatyne in press). Thermal emission recorded in the 8 to 14 micron range shows treeless peat plateaus as a warm or light-toned signature and a black spruce forest as cooler or dark coloured. Manipulation and thermal slicing of the images can be useful in identifying Sphagnum Bog.

Proposals to evaluate the application of newer remote sensing techniques for peatland inventory are being planned (Stewart personal communication). For example, digital image enhancement allows the principal component colour enhancement of Landsat imagery to be correlated with vegetative cover type units supported by aerial photography and groundtruthing analysis. The higher spatial resolution of current Landsat imagery and the capability to digitally correct the data increases its potential to become an operational technique in peatland inventories.

DATA COLLECTED

The kind of data collected from peatland inventories in Manitoba varies with the mapping scale and purpose for which the study was undertaken. Organic soil characterization in early soil surveys consisted mainly of a brief description of morphology with minimal chemical analysis. Recent soil surveys contain a greater number of chemical and physical analysis together with more detailed morphological description of organic soils (Mills and Smith 1971, 1981; Smith *et al.* 1975).

Soil surveys dealing specifically with the peatland environment present additional characterization of organic landforms, associated vegetation and water chemistry (Mills *et al.* 1977, Hopkins 1981). The following types of data are usually collected during soil surveys dealing specifically with peatlands:

1. Characterization and sampling of the organic soil series or association and establishment of its relationship with the peat landform.

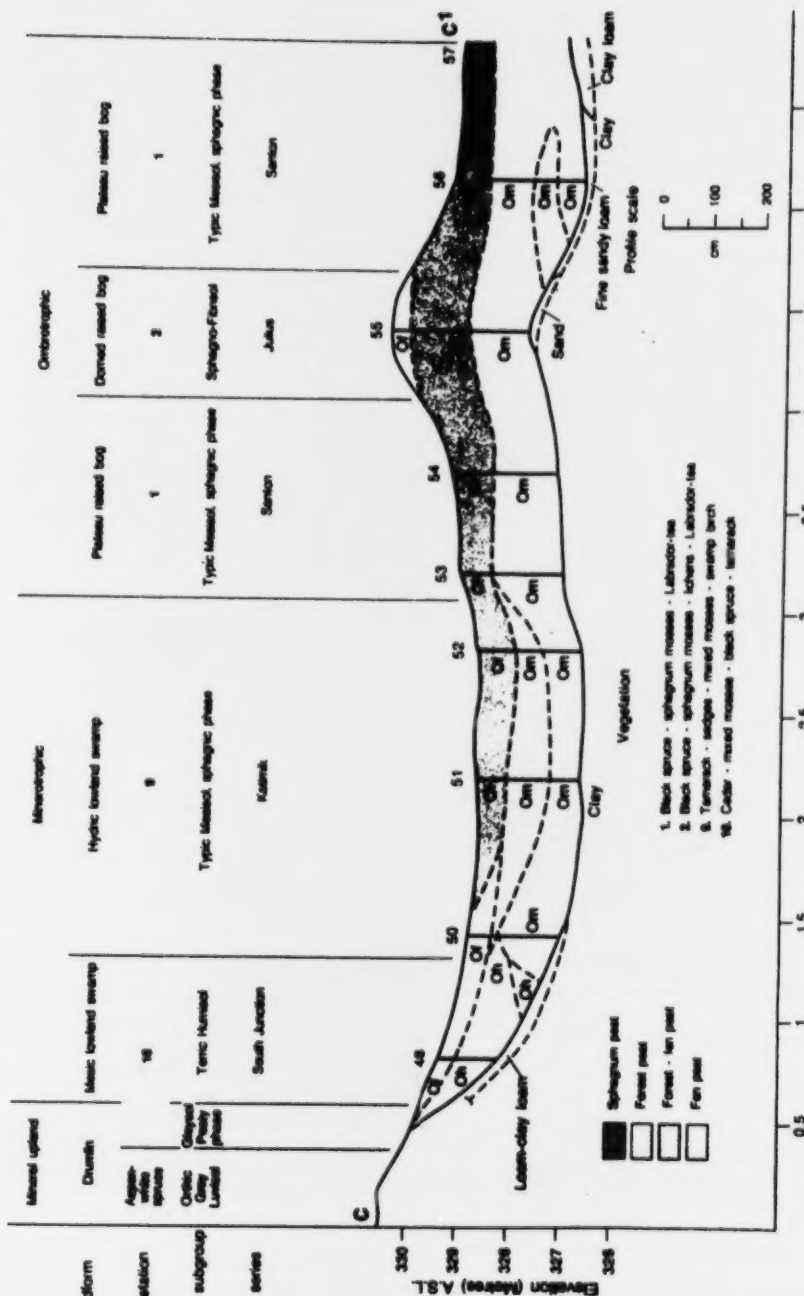


Figure 5: Cross section along transect C-C^1 in the Sprague Peatland (Mills *et al.* 1977).

Table 1: Soil legend of the Roseau River Watershed Map Area, Manitoba (Mills *et al.* 1977).

ORGANIC SOILS

MAP SYMBOL	SOIL NAME	PROFILE TYPE	ORGANIC PARENT MATERIAL KIND	DEPTH (cm)	UNDERLYING SUBSTRATE	DOMINANT LANDFORM	DOMINANT VEGETATION*
	Buffalo Bay	Typic Humisol	Mesic to humic forest	>130	undifferentiated	Mesic swamp	eC-Fm-bS-tL
	Baynham	Typic Mesisol	Mesic forest	>130	undifferentiated	Flat bog	bS-Er-Fm
Ca	Cayer	Terric Mesisol	Mesic fen	40-130	clayey	Horizontal fen	Cx-Dp
Cr	Crane	Terric Mesisol	Mesic fen	40-130	loamy till	Horizontal fen	Cx-Dp
	Cantyre	Terric Mesisol, sphagnic phase	Sphag for-fen & fen	40-130	loamy	Hydric swamp	tL-Cx-Mo-Bi
Gd	Grindstone	Terric Mesisol	Mesic forest	40-130	loamy till	Flat & sloping bog	bS-Er-Fm
Gd(sp)	Grindstone, shallow phase	Terric Mesisol	Mesic forest	40-90	loamy till	Flat & sloping bog	bS-Er-Fm
Ha	Haute	Terric Humisol	Mesic to humic forest	40-130	loamy	Mesic swamp	eC-Fm-bS-tL
	Halcrow	Terric Mesisol, sphagnic phase	Sphag for-fen & fen	40-130	loamy till	Hydric swamp	tL-Cx-Mo-Bi
	Howell	Terric Mesisol, sphagnic phase	Sphag for-fen & fen	40-130	clayey	Hydric swamp	tL-Cx-Mo-Bi
	Julius	Sphagno-Fibrisol	Sphagnum	>160	undifferentiated	Domed bog	bS-Sp-Er
Kc	Kircro	Terric Mesisol	Mesic fen	40-130	sandy	Horizontal fen	Cx-Dp
Kc(b)	Kircro, burnout phase	Terric Mesisol	Mesic fen	40-130	sandy	Horizontal fen	Cx-Dp
	Katimik	Typic Mesisol, sphagnic phase	Sphag for-fen & fen	>130	undifferentiated	Hydric swamp	tL-Cx-Mo-Bi
	Katimik drained phase	Typic Mesisol, sphagnic phase	Sphag for-fen & fen	>130	undifferentiated	Hydric swamp	tL-Cx-Mo-Bi
Lb	Lamb Lake	Terric Mesisol, sphagnic phase	Sphag mesic forest	40-130	loamy till	Flat & sloping bog	bS-Er-Mo
Mc	Macawber	Typic Mesisol	Mesic fen	>130	loamy till	Horizontal fen	Cx-Dp
Mh	Murray Hill	Terric Mesisol	Mesic fen	40-130	loamy	Horizontal fen	Cx-Dp
Mh(b)	Murray Hill, burnout phase	Terric Mesisol	Mesic fen	40-130	loamy	Horizontal fen	Cx-Dp
Ms	Marsh Complex	Rego Gleysol	Humic Aquatic	0-40	undifferentiated	Catchment marsh	Cx-Ty-Ph
Mu	Mud Lake	Terric Humisol	Mesic to humic forest	40-130	loamy till	Mesic swamp	eC-Fm-bS-tL
Ok	Okno	Terric Mesisol	Mesic forest	40-130	clayey	Flat & sloping bog	bS-Er-Fm
Or	Orok	Terric Mesisol, sphagnic phase	Sphag mesic forest	40-130	clayey	Flat bog	bs-Er-Mo

- organic soils are classified according to the Canadian System of Soil Classification (CSSC 1978). Soil and site descriptions are made as specified in the Manual for Describing Soils in the Field (1978). Analyses are carried out as specified by the Subcommittee on Methods of Analysis (1978). The classification used to describe peat landforms is part of the Wetland Classification included in the Canadian Wetland Registry (Tarnocai 1979).

2. Delineation of areal extent of the soil series or association on the photographs, maps and transects.

3. Vegetation characteristics associated with each soil series or association and peat landforms.

4. Drainage characteristics of the peatland.

5. Chemistry of the surface water.

6. Topography of the peatland.

7. Depth of the organic material to the underlying mineral strata and the peat stratigraphy of the peat landforms.

8. Nature of the underlying mineral material.

Other inventories specifically designed to identify Sphagnum bogs having potential for commercial development deal mainly with physical characterizations such as absorptive value, percent moisture, ash content, nitrogen content, pH, botanical composition colour and depth (Bannatyne 1980). This information is usually shown in tabular format which is referenced to detailed cross-sections of the peatland.

EXTENT OF INVENTORY COVERAGE

The extent of various terrain inventories in Manitoba is indicated in Figure 6. Most of the map information concerning organic soils and peat deposits in Manitoba is derived from surveys carried out by the Canada-Manitoba Soil Survey and the Geological Survey of Canada. The information generated by these surveys varies widely in content and cartographic detail according to the scale and the purpose for which the data was collected. Characteristics of the baseline data available from various peatland inventories in Manitoba is summarized in Table 2.

The most comprehensive description of the peatland environment is contained in surveys concentrating solely on specific peatlands. Detailed soil studies of peatlands providing inventory data indicating a measured peatland resource are available for a few selected areas in southeastern Manitoba (Mills *et al.* 1977 and Hopkins and Smith 1981). Very detailed surveys of individual peat landforms have utilized transects to provide a measure of the peat resource that can be exploited for commercial uses (Bannatyne 1980).

Map and descriptive information contained in reconnaissance scale soil surveys and ecological land surveys indicates the extent and location of peat resources with some measurement of their properties. Reconnaissance soil surveys covering 18 617 000 ha provide a fairly comprehensive description of the peatland environment in the southern half of Manitoba. Soil surveys prior to 1959 in this area generally contain less cartographic detail and associated descriptive information but most of these surveys do not contain extensive peatlands.

Broad reconnaissance level ecological classification is available for 12 521 000 ha in north central and eastern Manitoba. The scale of these surveys did not permit delineation of individual peatlands but rather repetitive patterns of organic landforms or organic and mineral landforms. Although, the descriptive material relating to the peatland environment in these surveys is often as detailed as that contained in recent reconnaissance soil surveys, only the map information, descriptive legend and brief summary narrative for each map sheet has been published.

Approximately 33 660 000 ha in northern Manitoba have not been mapped by reconnaissance soil survey or ecological land survey. Information on the peatlands of this area is inferred from broad exploratory soil surveys and surficial geology maps.

Exploratory soil surveys relying on limited groundtruth and extensive air photo interpretation provide a gross estimate of the extent of peatlands in northern portions of the Province. The scale of these surveys does not permit delineation of individual peatlands and there is very little characterization of the nature of these organic deposits. There are approximately 7 062 000 ha mainly in northwest and northeast Manitoba for which this broad exploratory information is the only terrain data available.

The surficial geology mapping program of the Geological Survey of Canada is primarily concerned with delineation of mineral surficial materials. However, terrain units containing

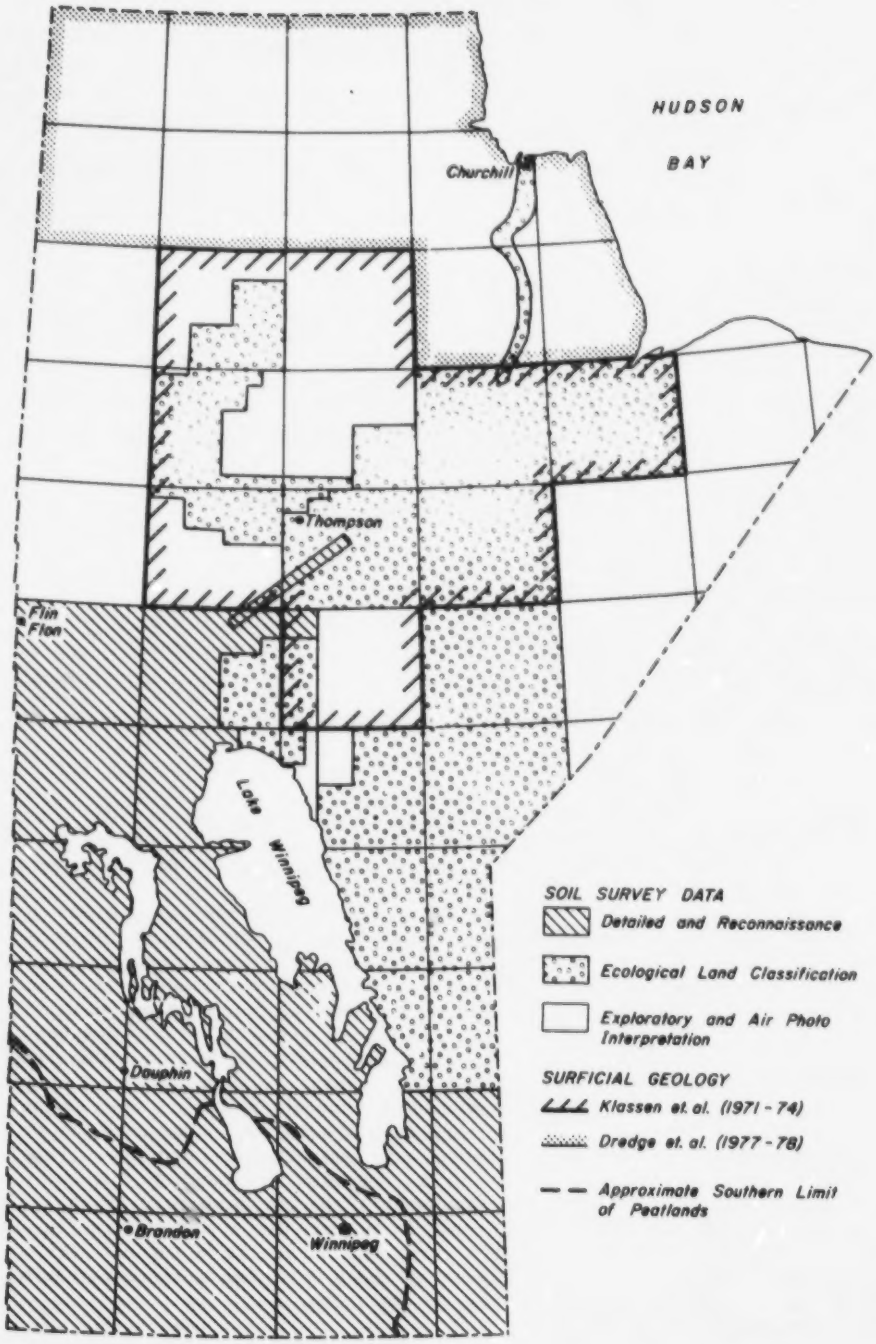


Figure 6: Extent of terrain inventories in Manitoba.

Table 2: Inventory coverage and characteristics of baseline data available for peatlands in Manitoba.

Survey intensity level	Map scale	Areal coverage[1] ha	%	Data characteristics and potential application
Very detailed	Transects	Selected sites	-	Detailed description of volume and quality for commercial management and exploitation
Detailed soil survey	1:40,000 to 1:63,360	69 000	-	Comprehensive description of individual peatlands suitable for planning for agriculture and forestry development, wildlife management
Reconnaissance soil survey	1:125,000	18 617 000	29	Indicates extent and location of peatlands with some measure of organic soil properties; suitable for regional and some local planning
Ecological land classification	1:125,000	12 521 000	19	Delineation of repetitive patterns of organic landforms, suitable for broad regional planning
Exploratory soil survey	1:1,000,000	7 062 000	11	Inferred data about extent, not specific to location, organic soil characteristics and volume
Surficial geology	1:250,000	26 600 000	41	Identifies terrain with significant amount of peatlands, description of genetic origin, active layer and ice content

[1] Because inventory coverage at different scales overlaps in some areas only the most detailed baseline data is cited.

significant amounts of organic materials are identified as to genetic origin of the organic landform (bog and fen) and their approximate proportion defined in terms of dominance or codominance. The active layer and ice content of organic materials containing permafrost is described but no other characterization of the materials is provided. This type of terrain information is available for 26 600 000 ha in northern Manitoba.

PEATLAND RESOURCES OF MANITOBA

According to the Canada Soil Information System (CanSIS) computerized data bank, peatlands consisting of organic soils having peat depths in excess of 40 cm, occupy some 107 986 000 ha or approximately 12% of the land surface in Canada. Of this area it is calculated that Manitoba has 20 664 000 ha of organic soils or 19% of the organic soils in Canada. Manitoba peatlands comprise 38% of the provincial land area and 32% of the total area (land and water). Earlier estimates by Ehrlich (1963) for the extent of peatlands in Manitoba differ only slightly (Table 3).

According to these data the area of peatlands in Manitoba ranks second to glacial till as the most extensive surface deposit.

The physiography of Manitoba combines with the prevailing climate over much of the Province to provide excellent conditions for the development of extensive peatlands. The distribution of these peatlands is shown in Figure 7. Peatlands predominate in poorly drained cool to cold humid areas of Manitoba where precipitation equals or exceeds evapotranspiration and in localized depressional areas where runoff from precipitation accumulates or moves very slowly over the land surface. Peatlands occur in greatest abundance in the cool to cold subhumid to humid regions of the Boreal Forest in eastern and central Manitoba and in the very cold Subarctic humid and perhumid areas of the Hudson Bay Lowland in northeastern Manitoba.

The distribution of peatlands in Manitoba shown in Figure 7, is generalized to the level of the baseline data available for northern Manitoba. More detailed information is avail-

Table 3: Summary of the estimated extent of various surface deposits, rock outcrop and water in Manitoba[1]

Kind of Surface Material	Area (000's) Acres	Hectares	Percent of Province
Glacial Till	53,100	21 506	33.2
Peatlands	47,760	19 341	29.8
Water	25,130	10 178	15.7
Lacustrine Sediments	19,760	8 003	12.4
Rock Outcrop	10,540	4 269	6.6
Gravel & Sand Outwash	3,710	1 503	2.3
Total	160,000	64 800	100.0

[1] Ehrlich, W.A. Surface Deposits and Soils of Northeastern Manitoba. Canada-Manitoba Soil Survey, Dept. of Soil Science, University of Manitoba, 1963.

able for areas where reconnaissance soil surveys and ecological and surveys have been completed (see Figure 6).

UTILIZATION OF PEATLANDS IN MANITOBA

Peatlands are a valuable resource capable of serving many uses including horticulture, agriculture, forestry, energy, industrial chemicals, sewage treatment, recreation, scientific study, wildlife, water filtration and preservation (Anon. 1981). However, utilization of peatlands in Manitoba is mainly in the native state. Black spruce for pulp production and local harvest of fence posts and rails are taken annually from accessible peatlands in southeastern and central portions of the Province. Peatlands take on an important role in providing wildlife habitat particularly in areas of the Province where uplands are developed for agriculture. Native use of the peatland environment by wildlife is not well documented.

Peatlands in their native state play an important role in water management affecting water quantity in several ways. Contrary to common belief, peatlands do not act as large sponges soaking up precipitation and slowly releasing it but rather delay stormwater runoff because of their level topography. Peatland vegetation increases evapotranspiration and further reduces the potential for more runoff (Anon. 1981).

Agricultural development of local areas of shallow organic soils has taken place along the northern and eastern fringes of present agricultural lands. Increased value of agricultural lands has made it feasible to drain wetlands including peatlands for agriculture.

Industrial and horticultural uses of peatlands has developed on a small scale in southeastern Manitoba. Bannatyne (1980) gives a brief history of the peat moss industry in Manitoba and summarizes annual production figures up to 1977. More than 90% of current production consists of peat moss for horticultural uses primarily for the export market. Production figures supplied by Bannatyne (Personal Communication)[1] indicate a continuing increase (Table 4) in annual production volume.

Table 4: Recent peat moss production in Manitoba[1]

Year	Short Tons	Tonnes	Value
1978	36,149		$ 3,952,855
1979	46,219		5,009,942
1980	68,232	61 900	7,541,121
1981(P)	96,000	87 000	11,500,000

(P) Projected

SUMMARY

Information concerning the extent and nature of peatlands in Manitoba varies widely. Characterization and mapping of these peatlands is incomplete over large areas and rather gener-

[1] Bannatyne, B.B. Personal Communication. Dept. of Energy and Mines, Manitoba.

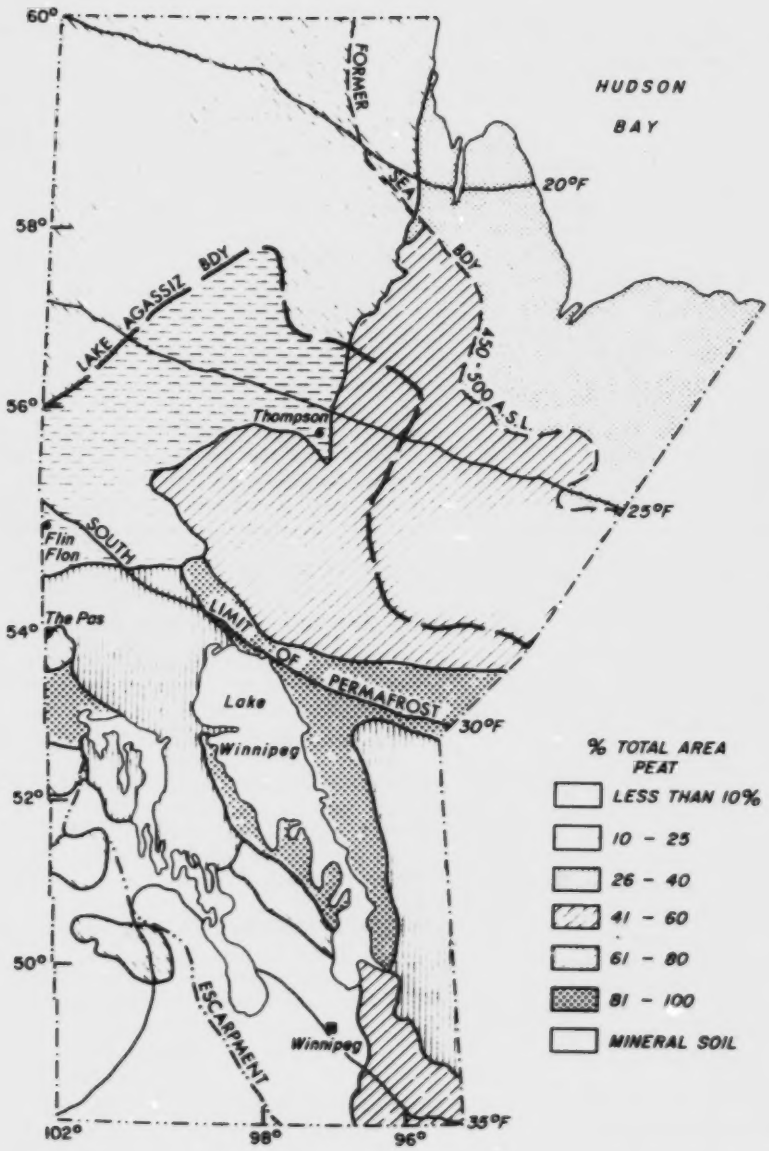


Figure 7: Map showing the distribution of peatlands in Manitoba (from Smith 1975).

alized in others. The most comprehensive and detailed inventory of peatlands in Manitoba is contained in recent soil surveys. These surveys provide a holistic description of the peatland environment, integrating peat landform, vegetation, soil and hydrology data into the mapping process.

There are no major inventories of peatlands ongoing in Manitoba at the present time although the soil survey has undertaken a resurvey of selected peatland areas in southeastern Manitoba. This resurvey program is at a detailed level (1:50,000 scale) and has been requested because of a growing interest in agricultural utilization of these peatlands within the climatically favourable areas of the Province.

Future peatland inventories must in addition to delineating the areal extent of peatlands, provide a reliable description of the depth and key characteristics of the organic deposits. Experience indicates that utilizing peat landforms as a mapping tool enhances the accurate, efficient and economic inventory of peatlands. In addition recent advances in remote sensing technology have potential to become an operational technique in peatland inventories.

A major data gap in the knowledge of Manitoba's peatland resource exists in northern portions of the Province. It is not possible to complete a uniform evaluation of peatland resources in Manitoba as some 33 600 000 ha in northern portions of the Province are not mapped by a systematic reconnaissance survey. Future inventories of peatlands should concentrate in those areas of northern Manitoba where deep peat deposits are common but for which reconnaissance inventories are not available.

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PEAT RESOURCE EVALUATION PROGRAM, PROVINCE OF ONTARIO

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ABSTRACT

Because of the vastness of the peatlands in Ontario the peat resource inventory program is proceeding on two levels. All peatlands of the Province are being mapped at a reconnaissance level using remote sensing methods based on aerial photography and satellite imagery. Peatlands for which there are development interests or opportunities are being evaluated in detail by field and laboratory methods similar to those already used in Finland and New Brunswick.

RÉSUMÉ

Vu l'immense superficie des tourbières de l'Ontario, nous entreprenons sur deux fronts l'inventaire de cette ressource. Nous produisons des cartes de reconnaissance de toutes les tourbières de la province, grâce à la télédétection (photographie aérienne et images transmises par satellite). Nous sommes en train d'évaluer en détail les tourbières pouvant présenter des possibilités de mise en valeur, au moyen de méthodes de terrain et de laboratoire semblables à celles qui sont déjà utilisées en Finlande et au Nouveau-Brunswick.

INTRODUCTION

A peat resource inventory program was initiated by the Ontario Geological Survey during 1981. It forms part of a larger Hydrocarbon Energy Resources Program (HERP) that is being funded over five years (1981-86) by the Ontario Board of Industrial Leadership and Development (BILD). Planning for HERP began in early 1980 following the Ontario government decision that the Province should increase its level of energy self-sufficiency (to 37.5% by 1995). The Ontario Ministry of Natural Resources, of which the Ontario Geological Survey is a major branch, was given responsibility for preparing an inventory of all indigenous hydrocarbon energy resources. These include conventional oil and gas, lignite, oil shale and peat.

As the Ontario Geological Survey had not had any previous involvement with fuel peat studies and, indeed, had only limited experience with any forms of peat inventories (e.g. Graham 1979), the first step in the process was an educational one. Joint funding was provided by the Ontario Ministries of Natural Resources, Energy, and Northern Affairs and a contract was awarded to Monenco Ontario Limited to carry out a review of the peat industry and a preliminary estimate of the Province's peat resources.

MONENCO STUDY

This study was designed to assess what was currently known about peat in Ontario and to evaluate mining methods applicable under northern climatic conditions, to evaluate peat processing methods, and to examine rehabilitation techniques. The current state of processing technology was reviewed, and the economics of peat as an energy resource, in comparison with other fuels, was assessed.

The study was completed in September 1981 and the report, titled 'An Evaluation of the Potential of Peat in Ontario' (Monenco Ontario Ltd. 1981) was published in October 1981. Release of the publication coincided with the International Symposium on Peat - An Awakening Natural Resource held in Thunder Bay and co-sponsored by the Ontario government and the Canadian National Committee of the International Peat Society.

Monenco estimates that Ontario's peatlands cover approximately 26 million hectares. The bulk of the peatlands lie within the Hudson

and James Bay Lowlands. It is estimated that about 9.9 million hectares are situated south of the southern limit of discontinuous permafrost.

It should be noted that these estimates are based only on measurements from available topographical and engineering geology terrain studies maps with no ground checking and only limited aerial photographic checking. Nevertheless, the estimates constitute an important first step in a comprehensive peat resource evaluation of the Province.

REMOTE SENSING METHODS

The vast size of Ontario's peatlands and the time and resources available for implementation of the program necessitate a much different style of inventory from those performed in other jurisdictions. In New Brunswick, for example, very detailed mapping of individual peat bogs has been carried out and virtually all peatlands of that Province have been examined at that level of detail.

While such detailed evaluation will be required for many of the peatland areas in Ontario, only regional reconnaissance will be necessary or practical for much of the Province. Rapid remote sensing methods are needed for this reconnaissance work and a system of peatland mapping developed by the Ontario Centre for Remote Sensing (OCRS) is currently being tested.

Called the Applicon mapping system, this method uses vegetation reflectance values obtained from Landsat data. A classification of these reflections, demonstrating the wetland types represented by the reflectances, was developed during mapping of the Hudson and James Bay Lowlands by OCRS during 1977-79.

The applicability of the classification to wetland areas on the Precambrian Shield and farther south in the Great Lakes - St. Lawrence Lowlands has not been confirmed definitively. Thus, during the past winter, several areas near Timmins and Sioux Lookout were mapped with the Applicon system and field crews will be conducting ground-truth work in one or more of these areas during summer of 1982.

Should the Applicon system prove to be successful in its objectives then it is planned to use it to provide at least reconnaissance coverage of all peatlands in the Province. It should be possible to complete this coverage in about three years (S. Pala, OCRS, Pers. Comm.).

For the Timmins and Sioux Lookout test areas the resultant maps are at 1:50,000 scale and the wetland areas are divided into four to eight categories depending on the complexity of the area and the level of detail required. The number of hectares represented by each category is provided automatically by the system.

In the Timmins area the following wetland types were identified and mapped:

open graminoid bog
open sphagnum bog
sphagnum bog - low density treed
- low shrub treed
- medium density treed
- high density treed
treed fen and bog complex
shrub-rich fen and bog complex.

In the Sioux Lookout area only the following four wetland types were shown:

open sphagnum bog
treed bog, open
treed bog, dense
fen.

As applied above, the Applicon mapping system at present only supplies the areal extent of each wetland category. However, this is still an extremely important refinement to the preliminary resource estimates and maps produced in the Monenco study.

PRIORITY AREAS

In addition to the testing and "ground-truthing" of the Applicon system, several peatland areas in northern and southeastern Ontario are to be mapped during 1982 by traditional resource evaluation methods. These are areas for which we have received specific requests from other government departments or private sector groups. They are areas in which peat mining developments are being considered and for which more detailed knowledge of available peatlands is needed.

The inventories to be undertaken in these areas will be modelled on the Finnish and New Brunswick peat resource evaluation systems. The principal objective will be to delineate the areal extent and volume (and hence tonnage) of suitable peat for energy and nonenergy applications.

Areas under consideration at present occur near Armstrong, Hearst, and Ignace in northern Ontario and near Peterborough, Pembroke, and Ottawa in southeastern Ontario. Additional

areas may be examined depending on the urgency of further requests and resources available to carry out the work.

It is planned to have these detailed resource inventories carried out by consultants on contract to the Ontario Geological Survey. As at least several consultants are likely to be used specifications are being designed to ensure standardized products from all areas. As mentioned above, these specifications will be based on the resource evaluation methods that are currently in use in Finland and New Brunswick.

FUTURE PLANS

Funding for the Hydrocarbon Energy Resources Program is expected to continue to 1986. Therefore it is intended to continue the peat inventory program to at least that time using the dual system described above. That is, it is intended to use the Applicon mapping system or other remote sensing methods (including traditional aerial photographic interpretations) for regional reconnaissance mapping while, at the same time, conducting detailed ground mapping of high priority areas.

By the middle to late 1980's it should be feasible to expect that all peatlands of Ontario will be mapped to at least a reconnaissance level and that all peatlands for which there are development interests will have been evaluated for area, volume and quality of the contained peat. The program will also continue to identify and evaluate peatlands that have development potential because of their ready accessibility, proximity to road, rail or lake transportation routes, and proximity to potential markets.

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WETLAND SYSTEMS OF THE CARIBOO-CHILCOTIN REGION OF B.C.

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ABSTRACT

The concept of a wetland system is developed. A wetland system defines the relationship between wetland classes (sensu Tarnocai 1979, Golet and Larson 1974, etc.) that occur as contiguous units within a single wetland area. Nine wetland systems are defined for the Cariboo-Chilcotin region of British Columbia. Descriptions, accessory and diagnostic characteristics are presented for both the systems and wetland components (classes) which make up the systems. Map units and map symbols are defined and correlation with the National Wetlands Registry is provided. Classification procedures and considerations and constraints for computer assisted classification are briefly discussed.

RÉSUMÉ

Nous avons mis au point un système de classification des termes humides dans lequel sont définies les relations qui existent entre les classes de terres humides (sensu Tarnocai 1979, Golet et Larson 1974, etc.) constituant des unités contigues à l'intérieur d'un même territoire. Neuf systèmes de terres humides sont de limités dans la région Cariboo-Chilcotin en Colombie-Britannique. Les caractères descriptifs, accessoires et diagnostiques sont présentés pour les systèmes et leurs composantes (classes). On définit en outre les symboles et les unités cartographiques ainsi que leurs rapports avec le répertoire national des terres humides. Les méthodes de classification et les restrictions imposées par la classification informatisée sont brièvement passées en revue.

INTRODUCTION

The classification and inventory of British Columbia wetlands has been the subject of considerable effort over the past few years. Increasing pressure from potential users of the wetland resource has stimulated interest in a wetland classification which could help in the resolution of potential use conflicts. Major concern to date has been wetland use for agriculture, wildlife, and waterfowl production. Suitability as a source for horticultural peat or fuel peat has as yet received little attention. Information on the vegetation, soils, and hydrology of wetland systems is central to the interpretive needs of nearly all identified users (Boreal Cariboo Subgroup on Wetlands 1978). It is unlikely that any single classification will meet all users' needs equally well, however, it should be possible to produce a classification which will facilitate the evaluation of alternative uses.

The activities of a number of agencies working on B.C. wetlands are summarized below:

Terrestrial Studies Branch, B.C. Ministry of Environment:

- no specific wetlands related work is being done, however, wetland soils and vegetation types are recognized as part of routine 1:50,000 and 1:100,000 inventory programmes.

- contracted the production of the "Preliminary Wetland Managers Manual" (Runka and Lewis 1981).

Range and Research Branches, B.C. Ministry of Forests:

- sampling and classification of vegetation and soil plots.

- testing of "Preliminary Wetland Managers Manual" (Runka and Lewis 1981).

- sampling and classification of major components of areas identified as wetlands on forest cover maps.

Fish and Wildlife Branch, B.C. Ministry of Environment:

- site specific habitat evaluation.

Agriculture Canada:

- soils of wetlands are recognized as soil associations on 1:125,000 reconnaissance level surveys.

- inventory of wetlands classed as organic, gleysol, or unknown based on Canada Land Inventory maps and 1:50,000 National Topographic Survey maps for the area between the Coast divide on the west, Rocky Mountains on the east, and the 49th and 53rd parallels.

- sampling and classification of wetland systems to define wetland map units at 1:10,000 to 1:50,000 inventories in the Cariboo-Chilcotin region.

- sampling and classification of wetland plots in the Kamloops and Fletcher Lake areas of British Columbia.

Ducks Unlimited:

- wetland specific inventories are conducted to evaluate potential habitat improvement. Two levels of inventory are used, the first to designate high potential areas while the second provides a detailed assessment of high potential areas. The approach is essentially a single use inventory and does not constitute a systematic inventory.

APPROACHES TO WETLAND INVENTORIES

Three basic approaches to wetland inventory are being used in B.C.

Attribute Inventories: List a number of attributes or attribute ranges which are found in each wetland area. These attributes may be such things as water types or depth, soil depth, degree of decomposition of organic materials, vegetation cover, etc.

Class Inventories: Specify combinations of attributes or attribute ranges which are used to define classes. These classes are used to characterize wetland areas. For example, a sedge dominated vegetative cover on organic deposits greater than 40 cm deep may be designated as a "fen". Wherever this combination occurs it can then simply be labelled "fen". Another form of class inventory may be termed interpretive inventory. Different combinations of attributes or attribute ranges are rated for some use and this rating is used to identify the wetland area. For example, certain combinations of water type, boundary vegetation, and boundary perimeter may be grouped as Class 1 for waterfowl nesting. The wetland is identified as Class 1, not as having a specific water type, boundary vegetation, and boundary perimeter.

System Inventories: Recognize that many wetlands have more than one significant set of attributes or attribute ranges and more than one significant class present. In addition a system inventory recognizes that the relationship and pattern of classes present in a wetland carries more information than a simple list of the classes or attributes and certainly more information than simply identifying the dominant class or listing the total range of attributes present. Figure 1 presents the relationship between attribute, class, and system inventories as well as the relationship between plots, classes, and systems. The system approach requires the identification of classes. Wetlands are then characterized by significant patterns and relationships of classes. The system approach is analogous to the catena or soil association approach used in soil mapping but interpretations are based as much on the system as they are on the classes which make up the system. Examples of each inventory approach are given below.

An attribute inventory as used by Ducks Unlimited is well suited to their needs. The evaluation of a wetland for waterfowl use can be based on the presence and quality of a limited number of attributes. The approach is successful because a limited range of interpretive needs must be met. As the number of interpretations increases so does the number of attributes which must be evaluated. At some point attribute inventories become prohibitive and classes must be defined to facilitate inventory procedures and data storage.

Inventories based on the classes defined in the "Preliminary Wetland Managers Manual" (Runka and Lewis 1981) or the organic soils mapped in the Peace River area (Report No. 8 of the B.C. Soil Survey 1965) are examples of class inventories. These inventories are useful when only one class is present in a wetland area, when only one of the classes present is of interest, or when the modification or interpretation of each class present can be treated in isolation of other classes which may be present. Some generalization and site specific information loss is inevitable in a class inventory.

When multiple classes are present in a wetland area and the classes cannot be evaluated in isolation from one another the system approach (Selby and Moon 1981) becomes useful. Since the system inventory is based on classes which now become components of a system it also

entails some site specific information loss as a result of generalization to the class or component level. Some of this information loss is, however, recovered since the ranges of attributes in a given class is much narrower within a system than it is between systems. For example, the organic soil thickness of a sedge dominated vegetative cover on organic material ranges from 10 cm to greater than 160 cm. When the class is found as a component[1] in one system the thickness ranges from 10 cm to 50 cm whereas when it is a component in another system it is rarely less than 50 cm in thickness. The components used in defining systems can also be used in a class inventory if such information is desired. For example, the individual components of a system could be mapped at a scale of 1:5,000 whereas only the system could be mapped at 1:20,000.

WETLAND SYSTEMS OF THE CARIBOO-CHILCOTIN

As indicated in Figure 1, a wetland system is defined as a diagnostic association and sequence of wetland components. The sequence is determined by evaluating components, in order, from the hydrologic low to the upland wetland transition. In order to classify a wetland system these diagnostic sequences must be identified. A total of eight vegetation sequences and six soil sequences have been used to define nine wetland systems. While both vegetation and soil sequences are diagnostic, the vegetation sequence alone will correctly classify greater than 80% of the wetland systems. This allows for fairly reliable classification when ground verification is not possible.

Vegetation sequences are characterized using a total of eleven physiognomic (structurally similar) components of which seven are diagnostic. Each of these components occupies a distinct position in a hydro-topographic sequence. A brief description of the eleven vegetation classes is given in Figure 2a. The eleven components were not all present in one system. An evaluation of observed patterns provided the assigned relative hydrologic positions. Deviation from the normal hydro-topographic sequence seems to indicate a change in the hydrology of the system.

Soil sequences are characterized by eight soil classes which are ranked in order of importance from sedimentary organic deposits through mineral. The sequence is defined by the most important soil component. A brief description of the soil components is given in Figure 2b. Two mechanisms of organic accumulation appear to be operating. Basin infilling as a result of sedimentation of either finely divided limnic material or non-Sphagnum moss at later stages is one mechanism. Marginal encroachment as a result of the buildup of sedge derived materials around basin margins is the second mechanism. Some systems show evidence of both mechanisms occurring concurrently.

The nine systems defined in this study do not cover all known wetland systems (Sphagnum moss dominated systems and forested systems were not studied) but do classify 99% of the 158 wetlands studied in the Cariboo-Chilcotin area. The nine defined systems are given geographical names in the same manner as soil map units. Such names quickly become connotative and avoid confusion with the wetland components or other existing classifications. Wetland systems may be subdivided into as many as three map units based on the dominance of diagnostic components. General descriptions with associated and diagnostic characteristics are provided for the nine defined wetland systems. Diagrams indicate the most common vegetation sequences (the components marked with an asterisk are diagnostic). The range of soil characteristics associated with each component are also shown. For more detailed descriptions of the component classification refer to Appendices 1 and 2. The nine wetland systems are also illustrated and described in detail in Appendix 3. Scientific and common names of plants are given in Appendix 4.

WETLAND MAP UNITS

Wetland systems are defined by the diagnostic sequence of wetland components. However, the proportion of a wetland occupied by each component varies between wetlands. Information on the relative dominance of the diagnostic components will be important for some management decisions. It has, therefore, been incorporated at the map unit level. Wetland systems are, with the exception of the Anthill system which has only one map unit, subdivided into three map units based on the dominance of the most central diagnostic component. For example, the Stum Lake system has three map units based on the dominance of the sedge component:

St1 - The sedge component is dominant and occupies greater than 50% of the wetland.

St2 - The sedge component is subdominant occupying 20-50% of the wetland.

[1] In classification terms the system being defined is also a class of a higher level (category) of classification. For this reason classes recognized in the class inventory will be referred to as components when systems are discussed.

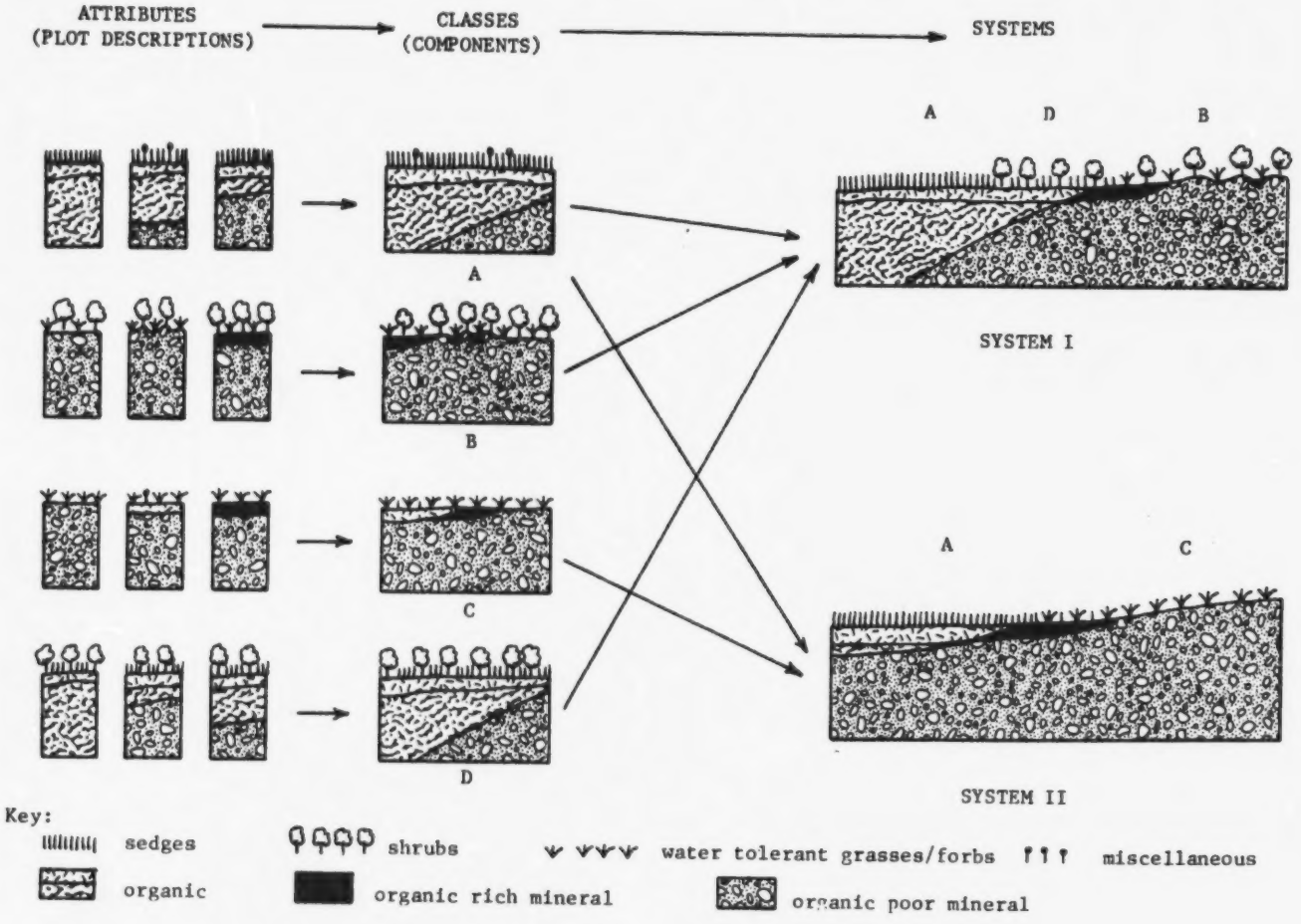
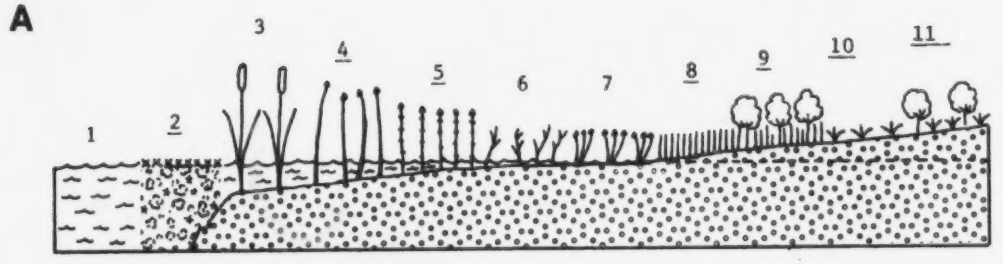
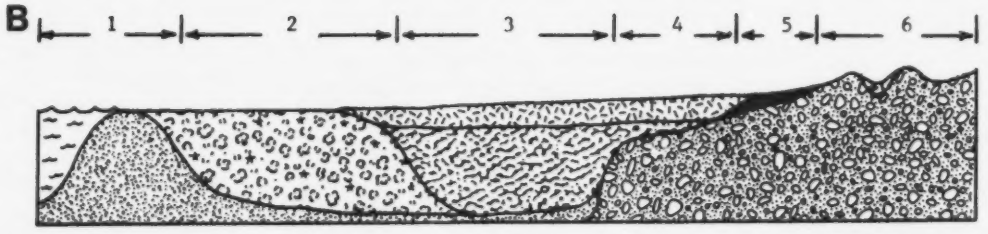


Figure 1: Relationship of attributes, classes and systems. The system is defined in terms of the sequence and combination of classes present. For example, the sequence A-D-B in System I would be a different system if the sequence were A-C-B.



1 permanent water 2 non-sphagnum moss 3 cattail 4 bulrush 5 horsetail
6 emergent grass 7 spike rush 8 sedge 9 shrub-sedge
10 water tolerant grasses and forbs 11 shrub-water tolerant grasses and forbs



water
finely divided sedimentary organic
fibrous non-sphagnum moss
mineral
fibrous sedge derived
moderately decomposed sedge
organic enriched mineral

Components

1. sedimentary 2. floating or supersaturated 3. organic 4. peaty-Gleysol
5. Humic-Gleysol 6. Mineral

Figure 2: (A) Relative hydrologic positions of the vegetation components used in the classification. Components are defined by the dominant ground cover. Components which are underlined are diagnostic in the definition of systems.

(B) Relative position of soil components used in the classification. Components are defined on the depth and nature of organic material. Two highly carbonated components were recognized but are actually carbonated variants of the types shown below and are therefore not shown.

St3 - The sedge component is a minor component of the wetland, occupying less than 20% of the system.

When the soil sequence differs from that defined for the wetland system a number modifier is added to identify the soil sequence.

The number used to indicate the soil deviation is the highest numbered soil component (see Appendix 2) present in the system. For example, Stl-4 is a Stum Lake system with a dominant sedge component on a peaty gleysol soil. The number 4 is used to indicate that instead of the expected sedge derived organic soil sequence a peaty gleysol soil sequence was found.

WETLAND MAP SYMBOLS

The wetland system and map unit do not account for a number of significant wetland characteristics. The presence and nature of aquic components, the water regime, and the degree of interspersion or boundary perimeter (Golet and Larson 1974) are therefore identified in the map symbol. Each of these variables is represented by a letter in the denominator of the map symbol. Definitions are as follows:

Aquic Component

Flowing (F):

the system is associated with a permanent flowing water body (stream or river)

Aquic (A):

the system is associated with a permanent standing water body (lake, pond, or puddle)

None (N):

the system lacks a permanent water body

Degree of Interspersion (defined by zonation patterns, see Figure 3)

Low (L):

zonation is concentric, concentric banded, or banded

Medium (M):

zonation is islanded or fingered

High (H):

zonation is interspersed

WATER REGIME

The relative water tolerance of each vegetation type was determined by analysing the hydrologic position in which each class occurred in relation to the other classes (Figure 2a). From this analysis five possible hydrologic systems were defined as follows:

Permanent (P):

Deep emergent vegetation (Cattail or Bulrush) present but lacking a moss component. Water level on the diagnostic unit is rarely at or below the surface. Fluctuations in depth of water are variable.

Floating (F):

Must contain either a moss component or a sedge component which has a floating sedge mat > 30 cm thick. Water level on the diagnostic unit fluctuates but the soil surface rises and falls with the water levels so that the soil is always saturated but never flooded.

Drawdown (D):

Emergent vegetation (Horsetail, Spike-rush, Manna grass, or other emergent grasses) present but lacking a deep emergent or floating component. Water level is below the soil surface for only short periods during the summer. Water levels are relatively stable during the remainder of the year.

Sedge or sedge-shrub classes represent the lowest hydrologic position in the wetland aside from the aquic component if present. Water level on the diagnostic units is at or below the soil surface for a significant portion of the growing season.

Ephemeral (E):

A water tolerant component is at the hydrologic low point of the wetland aside from the aquic component if present. Water level on the diagnostic unit is generally below the soil surface throughout the growing season. The diagnostic unit may be inundated for short periods in the spring.

Upland (U):

A shrub-grass/forb component class is the only water regime indicator present. Saturated conditions within 50 cm of the soil surface are rare. Gleyed colours or mottles are not present within 50 cm of the surface.

For example, $\frac{\text{Stl}}{\text{A-L-S}}$ is a concentrically zoned, lake or pond centred wetland with a sedge to shrub vegetation sequence on an organic soil. The sedge component occupies more than 50% of the wetland and the water regime is seasonal

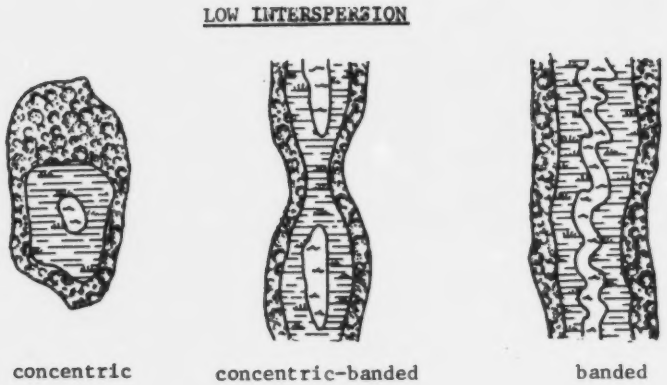


Figure 3: Vegetation zonation and interspersion classes.

(therefore no deep emergent or emergent components are present). Aerial survey can, with the exception of soil sequence deviations, provide the information required for the map symbol.

CORRELATION WITH THE NATIONAL WETLAND CLASSIFICATION

The wetland classification system incorporated in the Canadian Wetland Registry (Tarnocai 1979) is carried out on three levels. Mode and depth of organic deposition provides the basis for classification at the highest level (Class) while the general physiognomy of the vegetation cover is used as a subdivision criterion at the lowest level (Type). Using these two levels of the classification - the TYPE as a direct subdivision of the CLASS - it is possible to correlate the national classification with the component level of the system classification presented in this paper. The wetland component is defined by a soil class and a vegetation class (based on dominant physiognomy). In Table 1 those Classes and Types corresponding to components defined in the system classification are compared. The systems in which the component is the central diagnostic are also listed. The national classification does not evaluate patterns of associated classes therefore correlation at the system level is not possible.

CLASSIFICATION PROCEDURES

The classification and data handling procedures used to define the wetland classes are discussed in Selby and Moon (1981). Figure 4 summarizes the procedures followed. Vegetation plot data collected by Slavinski *et al.* (1979) were analysed using tabular analysis (Ceska and Roemer 1971). Nine vegetation classes and 28 vegetation subclasses, based on 200 plots, were defined. Following the classification of vegetation a multiple stepwise discriminant analysis (UBC:BMD07M) was performed using 27 soil variables to discriminate contrasting vegetation subclasses. Those variables showing the highest discriminating ability for vegetation were then used in defining soil components or classes. This was done by performing a cluster analysis (UBC:CGROUP

Table 1. Comparison of some of the National Wetland Classes and Types with the components defined in this classification.

National Wetland Classification		Component of the Wetland System Classification	
Class	Type	Vegetation Class on Soil Class	System
Fen	Sedge	Sedge on Organic	Stum L.
	Tall or Low Shrub	Shrub-sedge on Organic	Nimpo L.
	Moss	Moss (non-Sphagnum) on Floating Organic	Nazko L.
	Rush	Bulrush on Carbonated Organic	Sapeye L.
		Spike-rush on Carbonated Organic	none
		Cattail on Organic	none
		Horsetail on Sedimentary Organic	Anahim L.
	Grass	Emergent grass on Organic	none
Marsh	Sedge	Sedge on Peaty-Gleysol	Ragan L.
	Rush, Grass or Mixed Forb	Water Tolerant grass/forb on Mineral	Tatla L.
	Rush	Cattail on Mineral	none
		Spike-rush on Mineral	none
	Grass	Emergent grass on Mineral	none
		Emergent grass on Peaty-Gleysol	none
Shallow Water	Floating, Submerged or non-vegetated	Aquatic on Organic to Mineral	none
Non-Wetlands (puddles)	Grass or Mixed Forb	Water Tolerant grass/forb on Mineral	Tatla L.
Non-Wetlands (uplands)	Tall or Low Shrub	Shrub-grass/forb on Mineral	Anthill

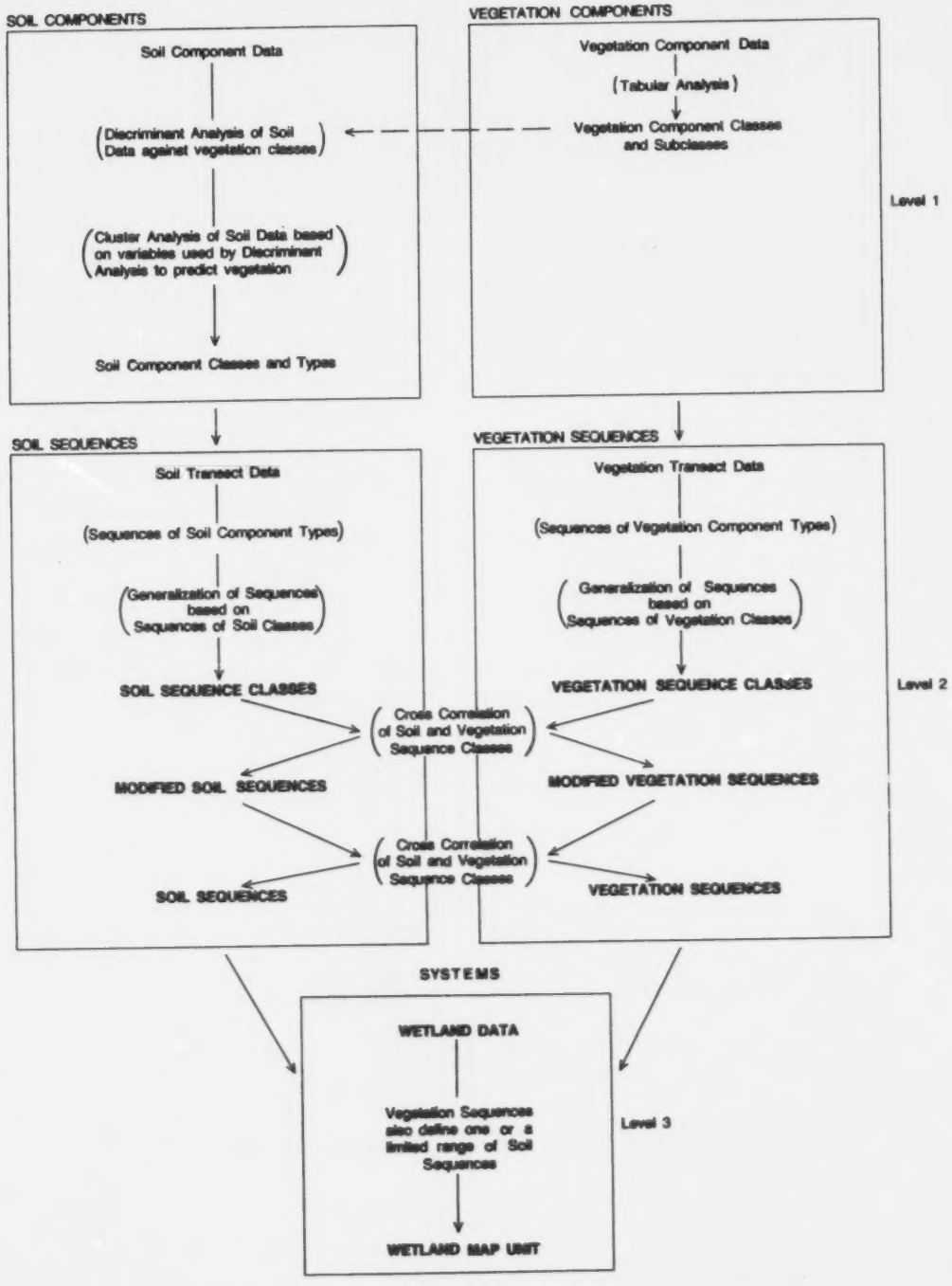

SOIL COMPONENTS
Soil Component Data
(Discriminant Analysis of Soil Data against vegetation classes)
(Cluster Analysis of Soil Data based on variables used by Discriminant Analysis to predict vegetation)
Soil Component Classes and Types
VEGETATION COMPONENTS
Vegetation Component Data
(Tabular Analysis)
Vegetation Component Classes and Subclasses
Level 1
SOIL SEQUENCES
Soil Transect Data
(Sequences of Soil Component Types)
(Generalization of Sequences based on Sequences of Soil Classes)
SOIL SEQUENCE CLASSES
MODIFIED SOIL SEQUENCES
(Cross Correlation of Soil and Vegetation Sequence Classes)
SOIL SEQUENCES
VEGETATION SEQUENCES
Vegetation Transect Data
(Sequences of Vegetation Component Types)
(Generalization of Sequences based on Sequences of Vegetation Classes)
VEGETATION SEQUENCE CLASSES
MODIFIED VEGETATION SEQUENCES
(Cross Correlation of Soil and Vegetation Sequence Classes)
VEGETATION SEQUENCES
Level 2
SYSTEMS
WETLAND DATA
Vegetation Sequences also define one or a limited range of Soil Sequences
WETLAND MAP UNIT
Level 3

Figure 4: Levels of integration and flow diagram of wetland classification.

of soil plots using the selected variables as grouping keys. The groups formed provided the basis of the soil component classification.

Following the definition of soil and vegetation components, a total of 112 wetland areas were characterized in terms of the sequence (from hydrologic low to upland) of wetland soil and vegetation components. A total of 191 transects were described and used in the sequence analysis. In addition 235 soil and vegetation components were sampled to test and refine class limits for the component classification. A number of techniques (Selby and Moon 1981) were used to define repetitive sequences of soil and vegetation. Several approximations were used in determining which components would be used as diagnostics for the sequences. The criterion used for evaluation was the degree of useful correlation between soil and vegetation sequences rather than components.

Wetlands were then evaluated in terms of the combination of soil and vegetation sequences found in the wetland area and the systems were defined using diagnostic sequences. Sequence and component data collected by Daubins and Thompson (1981) were used to test the resulting classification. Preliminary analysis indicates that 45 of the 46 systems showed the predicted soil and vegetation relationships and fit well into the wetland systems defined in this study.

COMPUTER ASSISTED CLASSIFICATION - CONSIDERATIONS AND CONSTRAINTS

This project has demonstrated a number of advantages and limitations which bear consideration for future inventories. Computer assisted data analysis allows for rapid treatment of large volumes of data. This means that class limits and class concepts can be readily developed from, or tested against, the entire data base. They can also be developed using one data subset and tested against another subset. The ease of data retrieval and manipulation facilitates the use of multiple classification strategies and simplifies updating and testing when classifications change. Numerical approaches to classification often reveal patterns and relationships which the investigator may have missed due to inexperience, previous bias or simply the inability to deal manually with a large data base. Finally, rigorous evaluation of the results often points out data discrepancies which might otherwise be missed.

Efficient handling of the data does, however, impose a number of constraints and requirements. The use of computer assisted classification requires a clear understanding of the classification objectives and available data handling techniques which may place restrictions on data types, forms or formats. The design and implementation of the data collection program should include a reconnaissance survey to identify the important variables and their expected ranges since all variables considered must be unambiguously and consistently defined and measured. This is especially important where class data rather than continuous variable data is collected. Care must be taken to record a value for all variables at all sites because missing data seriously limits the usefulness and ease of data analysis.

The format for data collection may present problems in data analysis. Inappropriate coding formats and file structures can result in serious limitations on the kinds of analyses which can be done. For example, analysis of the component sequences to determine the relative hydrological position of each component required that the data be collected in the precise order of occurrence. Had a specific sequence of recording components been used, any sequences which did not correspond to the coding sequence would have been lost. In some cases ease of analysis is influenced and although the problems are not insurmountable, their solution may require "Programmer Intervention!" which might result in unnecessary delays.

The question of data base management also requires consideration. The establishment of "relations" or ties between data sets should be examined prior to the data collection phase. For example, specific soil descriptions cannot be tied to specific wetland areas or polygons unless the relation is coded. Thus the relation must be included in the data format and file structure.

There is a very real danger that "number crunching" will become an end in itself. Data transformations and "computer gymnastics" can easily remove the systems under study from the real world. Results must be critically evaluated, transformed to real world equivalents, and tested in the field before they can be of use in inventory, mapping, or interpretation.

CONCLUSION

The classification presented here meets many of the inventory and interpretive needs for which it was designed. It cannot and was not intended to replace site and discipline specific investigations. Hydrology is only indirectly and briefly assessed, and the feasibility of many, if not most, management

options may require a more thorough assessment of hydrology. The classification will need to be modified or expanded as new systems are investigated but it is consistent with data already collected. We believe that it provides a useful tool for establishing resource priorities and concerns (excluding water management) in the Cariboo-Chilcotin area.

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APPENDIX 1: VEGETATION COMPONENT CLASSES

Eleven vegetation cover types were defined for the Cariboo-Chilcotin region of British Columbia. Tabular analysis was performed on 207 detailed plots and the resulting releve types were grouped into physiognomically similar cover types. These cover types were used to define vegetation component classes which were tested with an additional data set of 230 plots. When a component is a complex of two types it is classified by the dominant type. The following definitions are a modification of those presented in the provisional classification (Moon and Selby 1981).

Aquatic

- Includes areas of permanent open water, open water with rooted or floating aquatic species such as water lily (Nuphar polysepalum) and pondweed (Potamogeton spp.) or with submerged aquatics such as bladderwort (Utricularia vulgaris) or water-milfoil (Myriophyllum spp.), and areas of sparsely or non-vegetated mudflats exposed during drawdown.

Moss

- Ground cover is dominated by non-Sphagnum brown moss (generally Drepanocladus spp.) which is easily visible through an open herbaceous stratum of woolly-fruited sedge (Carex lasiocarpa), spike-rush (Eleocnaris spp.), cotton-grass (Eriophorum spp.), and buckbean (Menyanthes trifoliata.

- Woody shrubs (willow [Salix spp. and birch Betula glandulosa]) of low stature may be present but do not form a dominant shrub stratum.

Cattail

- Dominant cover is a uniform, often pure stand of cattail (Typha latifolia). Cattail is an erect, rooted herbaceous hydrophyte that is frequently over 1 m in height.

- Found in areas of standing or slow moving water where it may be associated with aquatic species.

Shrub-Sedge

- Dominant cover is a combination of shrubs and sedges. The shrub layer includes wood plants less than 6 m in height and must cover at least 15% of the ground surface. Dominant shrubs include scrub glandular birch (Betula glandulosa) and willows (Salix spp.). The herb cover is dominated by tall sedges such as water sedge (Carex aquatilis), beaked sedge (C. rostrata), or awned sedge (C. atherodes). Mosses such as Aulacomnium spp. and Tomenthypnum spp. may also be abundant.

Water Tolerant Grass/Forb

- Dominant cover is a mixture of grasses, forbs (herbaceous plants), and grass-like species (dryland sedges and rushes). Two subclasses are defined by the dominant species:

  Alkaline: Tolerant dominants include alkali saltgrass (Distichlis stricta), alkali grass (Puccinellia spp.), alkali cordgrass (Spartina gracilis), and seablite (Sueda depressa), with arrowgrass (Triglochin maritima) and associated species such as foxtail barley (Hordeum jubatum). Salt crusts are often present on the soil surface.

  Non-alkaline: Dominants include Arctic rush (Juncus arcticus), clustered field sedge (Carex praegracilis), foxtail barley (Hordeum jubatum), Kentucky bluegrass (Poa pratensis), mat muhly (Muhlenbergia richardsonis), common silverweed (Potentilla anserina), dandelion (Taraxacum officinale).

Shrub-Grass/Forb

- Dominant cover is a combination of shrubs and a mixture of grasses, forbs, and grass-like species. The shrub stratum includes woody plants less than 6 m in height and covering at least 15% of the ground surface. Dominant species include scrub glandular birch (Betula glandulosa) and willows (Salix spp.). The herb cover includes assorted grasses (Koeleria macrantha, Agropyron spp., etc.), Arctic rush (Juncus arcticus), field sedge (Carex praegracilis), and numerous forbs: yarrow (Achillea millefolium), anenome (Anenome multifida), wild strawberry (Fragaria virginiana), meadow-rue (Thalictrum occidentale), etc. Mosses are often present in depressions.

Horsetail

- Dominant cover of swamp horsetail (Equisetum fluviatile) with a scattered occurrence of hemlock water-parsnip (Sium suave), marsh cinquefoil (Potentilla palustris) and assorted aquatics such as duckweed (Lemna spp.).
- Generally found in shallow standing water.

Emergent Grasses

- Dominant cover is a uniform, often pure stand of hydrophytic grasses such as manna grass (Glyceria spp.), short-awned foxtail (Alopecuris aequalis), slough grass (Beckmania syzigachne) or spangletop (Scolochloa festucacea).
- Associated species with a low cover include pondweed (Potamogeton spp.), spike-rush (Eleocharis spp.) and sedges (Carex rostrata).

Spike-Rush

- Dominant cover of spike-rush (Eleocharis palustris) with scattered occurrences of water smartweed (Polygonum amphibium), and assorted grasses (e.g. Beckmania syzigachne, Glyceria spp., and Hordeum jubatum).

Sedge

- Dominant cover of sedges forming dense, uniform stands of one or more of the tall sedges - water sedge (Carex aquatilis), beaked sedge (C. rostrata), or awned sedge (C. atherodes). Mosses may be present under the dense sedge cover.
- May be found in shallow standing water, especially early in the growing season.

APPENDIX 2. SOIL COMPONENTS.

The soil descriptions are arranged so that the first description to fit the soil in question identifies the soil class. Diagnostic characteristics are indicated with an asterisk.

ORGANIC SOILS

* These soils have greater than 30 cm† of organic material over mineral soil.

1) Moss (Non-Sphagnum) Derived Organic Soils

* Organic materials are dominantly moss derived (greater than 40% of the organic material in the 160 cm control section).

- Soils are floating or supersaturated and have a characteristic springiness when walked on.
- The matrix of moss derived materials often contains a significant component of limnic materials.
- Soil great groups may be:
  Typic Fibrisols
  Humic Fibrisols
  Mesic Fibrisols
  Terric Fibrisols
  Orthic Gleysols (rarely)

2) Highly Carbonated (Marl-like) Organic Deposits

* Organic materials are dominated by carbonated deposits in the rooting surface.

- Soils may originally be sedimentary (limic), sedge, or moss derived but are so enriched in carbonates that the properties are more characteristic of mineral soils.
- Soil great groups may be:
  Humisols
  Mesisols
  Fibrisols
  Orthic Gleysols (rarely)

3) Sedimentary (Limnic) Organic Soils

* Organic materials are sedimentary deposits (greater than 40% of the organic material within the 160 cm control section).

- Sedimentary materials are finely divided organic detrital (Oh) sediments with amorphous or granular structure.
- Soil subgroups may be:
  Typic Humisols
  Mesic Humisols
  Fibric Humisols
  Terric Humisols
  Orthic Gleysols (rarely)

†Depth limits do not correspond to the Canadian System of Soil Classification. Data analysis demonstrated three depth populations 0-30 cm, 30-90 cm, and greater than 90 cm.

4) Sedge Derived Organic Soils

* Organic materials are dominantly sedge derived (greater than 60% of the organic material within the 160 cm control section).

- Soil subgroups may be:
  Typic Mesisols
  Fibric Mesisols
  Terric Mesisols
  Less frequently Typic Fibrisols or
  Orthic Gleysols

MINERAL SOILS

* Soils with a 0 to 30 cm‡ thick surface capping of organic (Of, Om, Oh) material.

5) Peaty Phase Mineral Soils

* Have a 5 cm to 30 cm thick capping of organic (Of, Om, Oh) materials.

- Soils may be subdivided on the nature of the organic surface, for example, fibric, mesic, or humic peaty phase Gleysols.

- Characteristics of the mineral soil will be important to management but are not considered at this level of the classification.

- Soil subgroups may be:
  peaty Humic Gleysols
  peaty Rego Humic Gleysols
  peaty Orthic Regosols
  peaty Humic Regosols

6) Marl

* Nearly pure $CaCO_3$, $MgCO_3$, or $CaCO_3$-$MgCO_3$ deposits greater than 30 cm thick.

7) Mineral-Organic Transition Soils

* Have gleyed colours (Munsel 2.5Y to B hues) within 30 cm of the mineral surface.

* Have organic matter enriched (Ahg) mineral surface greater than 5 cm thickness.

- When the mineral surface is silty or clayey the Ahg may be confused with an organic (Oh) surface. It can be distinguished by a degree of plasticity not evident in organic soils and by a lack of compressability which is generally evident in Oh horizons.

- Soil subgroups may be:
  Humic Gleysols
  Rego Humic Gleysols
  Humic Regosols

8) Upland Transition Soils

* Do not show gley colours (Munsel 2.5Y to B hues) within 30 cm of the surface.

- Generally do not have organic or organic enriched mineral surfaces thicker than 5 cm.

- Frequently show significant disturbance as a result of ant mounding which disrupts horizonation.

- Soil sub-groups may be:
  Orthic Gleysols
  Gleyed Melanic Brunisols
  Gleyed Eutric Brunisols

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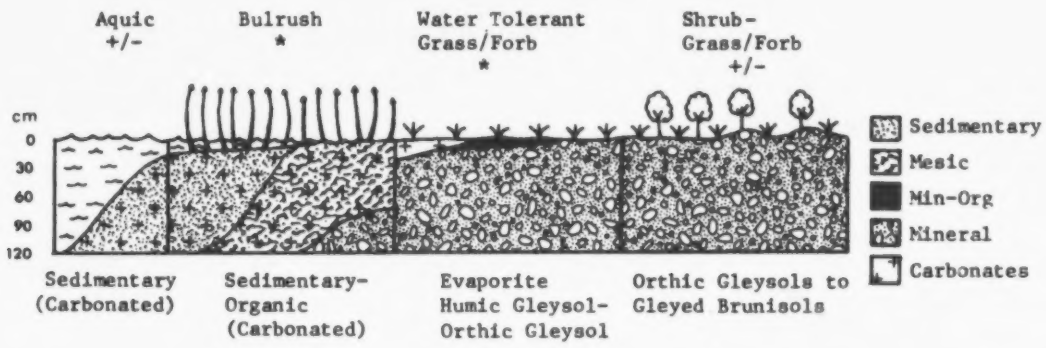
‡Depth criteria are not consistent with the Canadian System of Soil Classification (CSSC). Data analysis demonstrated that the CSSC depth breaks were inappropriate to the systems studied.

APPENDIX 3: WETLAND SYSTEMS DEFINED FOR THE CARIBOO-CHILCOTIN REGION OF BRITISH COLUMBIA.

SAPEYE LAKE SYSTEM



Description

The Sapeye Lake system is characterized by a bulrush to water tolerant grass/forb sequence. The bulrush generally occupies greater than 20% of the wetland area and occurs on a highly carbonated (marl-like) organic soil that may be sedimentary or mesic organic material. The water tolerant component is found on organic matter enriched mineral soils (Humic Gleysols) or mineral soils. An alkaline tolerant grass/forb component on magnesium or calcium carbonate evaporite deposits may be the water tolerant component present. A shrub-grass/forb dominated mineral component is likely to be present but is not considered diagnostic.

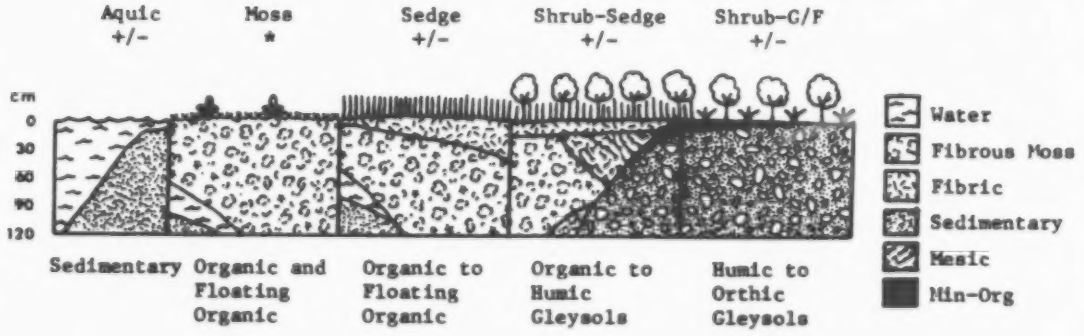
Associated Characteristics

The vegetation of the Sapeye Lake system, which is characteristic of mineral systems, is a response to the very high levels of carbonates found in the organic soil components. These high carbonate levels cause organic soils to show properties similar to mineral soils. Bulrush was generally found growing on mineral rich substrates and its presence in organic wetland systems indicates very high carbonate levels. Sampling indicates that arrowgrass may substitute for bulrush in the Sapeye Lake system.

Diagnostic Characteristics

A bulrush (possibly arrowgrass) dominated component, on highly carbonated organic soils, occupying greater than 20% of the area and bounded by a water tolerant grass/forb component is diagnostic. A sedge or shrub-sedge component cannot be present.

NAZKO LAKE SYSTEM



Description

Nazko Lake systems have a moss dominated component. The moss cover type is composed of non-Sphagnum mosses (generally Drepanocladus spp.) which form a complete surface cover. Low covers of woolly-fruited sedge, herbs (characteristically buckbean) and cotton grass are frequently present. Occasional (< 5% cover) small willows may be present in the herb strata. Soils of the moss component are weakly decomposed moss material, they are frequently floating and often have significant amounts of sedimentary (finely divided) organic material in the matrix. The moss component is usually associated with a sedge and/or shrub and sedge dominated component. The sedge component may be floating on a supersaturated sedimentary organic layer. The soil will generally be moss derived organic material with a variable depth sedge derived capping. The shrub-sedge component does not float and may grade to a sedge derived organic, peaty Gleysol, or infrequently an organic enriched (Humic Gleysol) mineral soil when adjacent to a shrub and water tolerant grass/forb component.

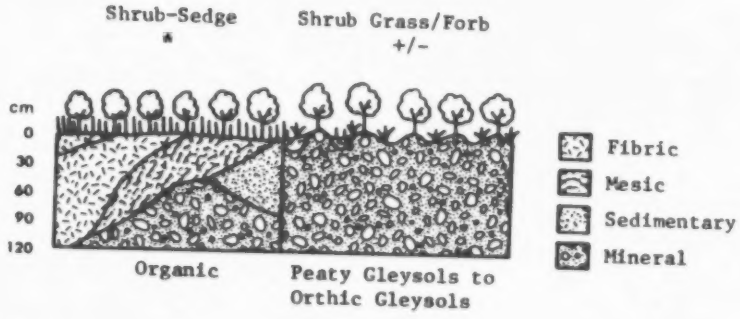
Associated Characteristics

The Nazko Lake systems studied were lake centred and showed a characteristic "springiness" when walked on. They are floating or supersaturated and the surface of the moss component rises and falls in response to changes in water table levels. The Nazko Lake systems appear to be the product of lake infilling, rather than encroachment from the lake margin, but both processes are probably active. The sedge to shrub sequence characteristic of the Stum Lake system may also be present and it is possible that Nazko Lake is a compound system. If future studies demonstrate that Nazko Lake systems frequently lack a sedge to shrub sequence, a new wetland system should be defined.

Diagnostic Characteristics

The Nazko Lake system must have a moss component with a moss derived, floating or supersaturated organic soil.

NIMPO LAKE SYSTEM
(6% of systems sampled)



Description

Nimpo Lake systems have only shrub dominated components. A shrub and sedge dominated component must be present and sedge, moss, and bulrush dominated components must be absent. Soils associated with the shrub and sedge dominated component are organic (> 40 cm deep) but show a wide range of characteristics. Organic materials range from poorly to moderately decomposed or sedimentary at all depths. The shrub-sedge component may be bounded by a shrub-grass/forb component which will usually be on a strongly mounded mineral soil. The area between the two components will show a gradual transition with shallow organic (< 15 cm) deposits in the depressions between mounds, grading to Humic Gleysols and Gleysols.

Associated Characteristics

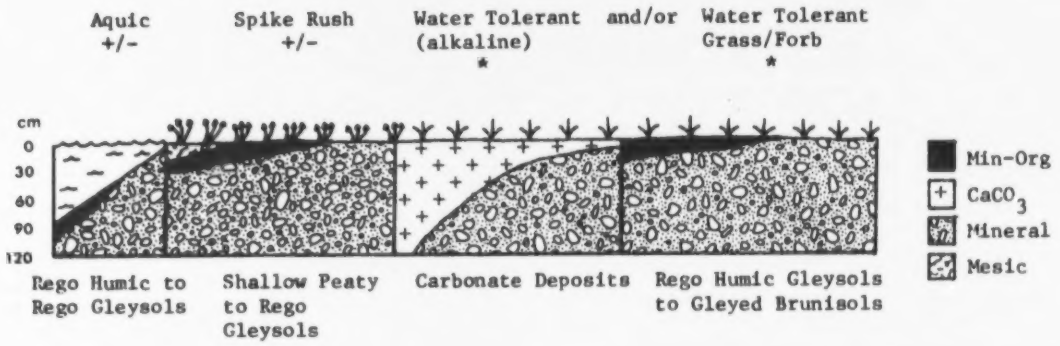
Aquic centres are not common as the Nimpo Lake system seems to be associated with seepage tracks. Nimpo Lake systems probably represent later successional stages of Stum, Ragan, and Nazko Lake systems. This would explain the

wide range of organic soil types found in the Nimpo Lake system. Nimpo Lake systems probably occur more frequently than sampling would indicate and may show a wider range of characteristics than defined.

Diagnostic Characteristics

The shrub and sedge dominated component is diagnostic. Only shrub-sedge and shrub-grass/forb components may be present.

TATLA LAKE SYSTEM
(15% of the systems sampled)



Description

The Tatla Lake system has a water tolerant grass/forb component and lacks sedge, bulrush, or moss components. Soils associated with the water tolerant component often show organic rich mineral surfaces (Ahg) and are poorly drained mineral soils. Soils showing very high levels of carbonate enrichment and supporting an alkaline tolerant form of the water tolerant grass/forb cover type are frequently present and are also diagnostic. An emergent (spike-rush) component, while not diagnostic, is frequently present and indicates areas of more prolonged saturation. Sampling was inadequate to separate alkaline or saline systems.

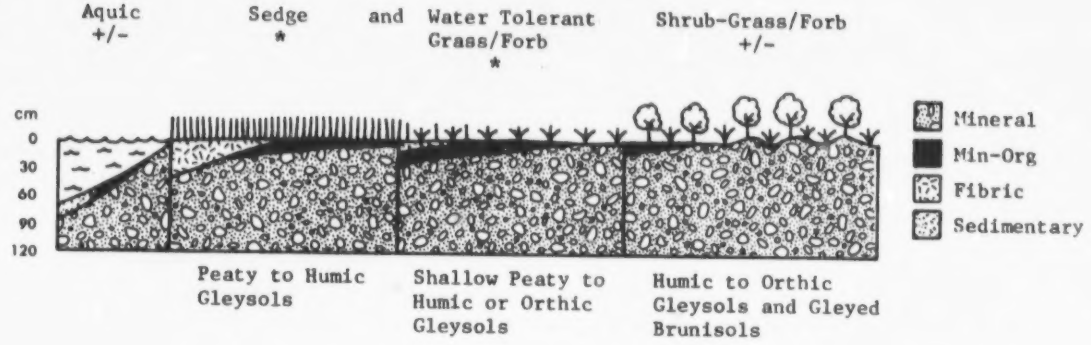
Associated Characteristics

Aquic centres are frequently present and the Tatla Lake system often shows pronounced zonation in the water tolerant grass/forb component. At least part of this zonation seems to be a response to the influence of water levels on grazing patterns. Distinct bands of dandelion or fox-tail barley, often marginal to a shallow pond, appear to mark the lowest point of grazing while the soil was still saturated. Evidence of soil mixing and organic matter incorporation indicate that while the soil bearing strength is low due to saturation, cattle grazing causes serious disturbance and mixing. As the soil dries these areas provide suitable habitat for aggressive colonizers. The water tolerant grass/forb sequence may be found on organic soils. Where this is true it is probable that the water table has been lowered.

Diagnostic Characteristics

The Tatla Lake system must have a water tolerant grass/forb, either alkaline tolerant or non-alkaline tolerant, component. It will not have a sedge, cattail, shrub-sedge or moss component present.

RAGAN LAKE SYSTEM
(25% of the systems sampled)



Description

Ragan Lake systems have a central diagnostic component which is sedge dominated and lacks shrubs. Soils associated with the sedge component are dominantly shallow fibric organic deposits (< 30 cm) to organic rich mineral surfaces. The fibric nature of the organic surface is due to a dense sedge root mat. Bounding the sedge component is a water tolerant grass and/or forb dominated vegetation component. The associated soils range from very shallow fibrous organic surfaces through organic matter rich (Ahg) to organic matter poor mineral surfaces. The water tolerant grass/forb component is often bounded by a shrub-grass/forb component with soils ranging from organic matter rich surfaces to gleyed mineral soils. The shrub-grass/forb component when present is rarely, if ever, inundated.

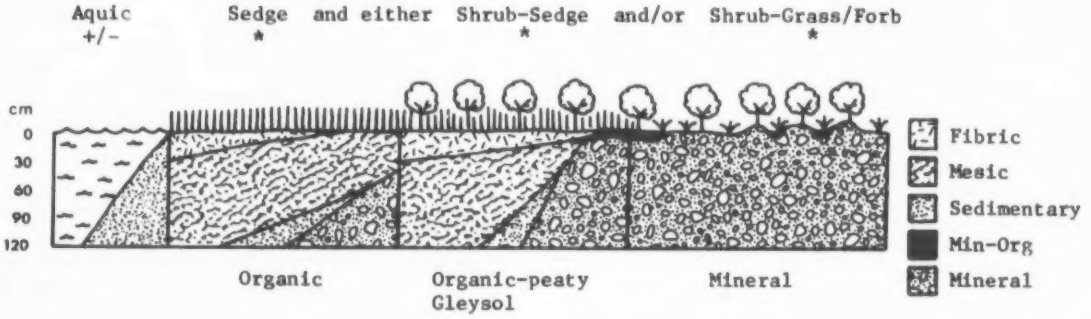
Associated Characteristics

An aquic centre may or may not be present. The presence of an emergent grass component probably indicates areas of more prolonged inundation. Organic materials may occasionally be highly carbonated. Mounds in the shrub-grass/forb area are generally anthills.

Diagnostic Characteristics

The sedge to water tolerant grass/forb sequence with peaty Gleysol or Humic Gleysol soils is diagnostic. Shrub-grass/forb components if present must be separated from the sedge component by a water tolerant grass/forb component.

STUM LAKE SYSTEM
(27% of sampled systems)



Description

Stum Lake systems have a central diagnostic component which is sedge dominated and lacks shrubs. Soils associated with this component are generally deep (> 60 cm) moderately decomposed (Mesisol) organics with a fibrous surface up to 30 cm thick. The fibrous surface is the result of a dense sedge root mat. Layers of sedimentary peat may be found below the sedge derived deposits. The sedge component is bounded by a shrub (willow and/or birch) component. The shrub component may be a mixed shrub and sedge (shrub-sedge) cover type on soils ranging from those associated with the sedge component to peaty Gleysols (< 40 cm of organic material) and rarely organic rich mineral soils (Humic Gleysols). Alternatively a shrub and water tolerant grass/forb (shrub-grass/forb) cover type on soils which range from organic rich mineral surfaces to smooth or mounded gleyed mineral soils may bound either the sedge or shrub-sedge component.

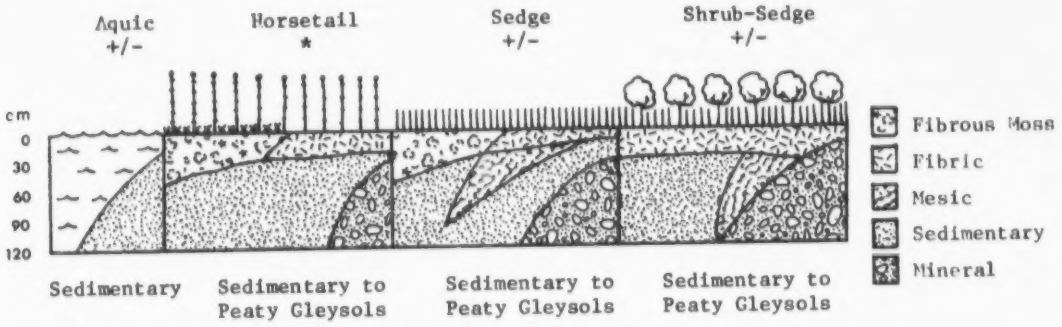
Associated Characteristics

The Stum Lake system may or may not be aquic centred and is only rarely aquic to cattail centred. The presence of spike-rush or emergent grasses may reflect areas of more prolonged flooding than in the sedge or shrub areas. The Stum Lake system appears to be the product of marginal encroachment rather than basin infilling of organic material.

Diagnostic Characteristics

The sedge to shrub vegetation sequence with an organic surface greater than 30 cm deep in at least one component is diagnostic for the Stum Lake system. Smaller systems (< 0.5 ha) may be peaty Gleysol soil sequences and represent a shallow variant of the Stum Lake system.

ANAHIM LAKE SYSTEM



Description

The Anahim Lake system has a component (> 20% of the area) dominated by horsetail or horsetail and moss cover on a non-floating moss or sedimentary peat deposit. The horsetail component is bounded by a sedge or shrub-sedge dominated component occurring on the same range of soils or on sedge derived mesic deposits resulting from marginal encroachment rather than basin infilling. A sedge to water tolerant grass/forb component may (less frequently) be present.

Accessory Characteristics

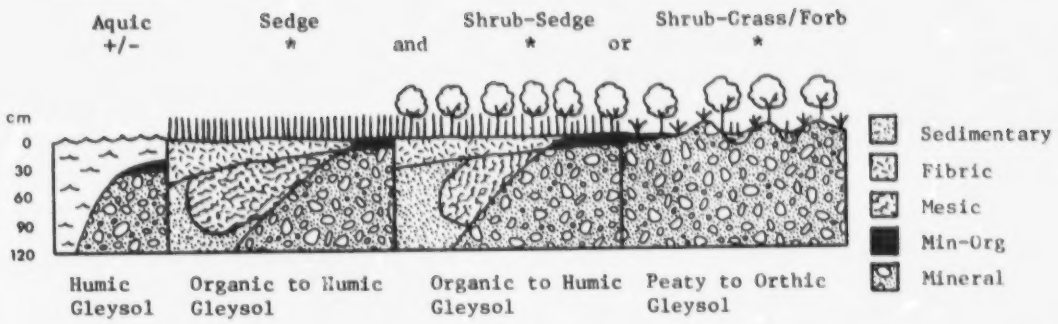
The Anahim Lake system shows characteristic basin infilling and is similar to the Nazko Lake system in this respect. Unlike the Nazko Lake system it is not floating or supersaturated; therefore the surface may be inundated for prolonged periods.

Diagnostic Characteristics

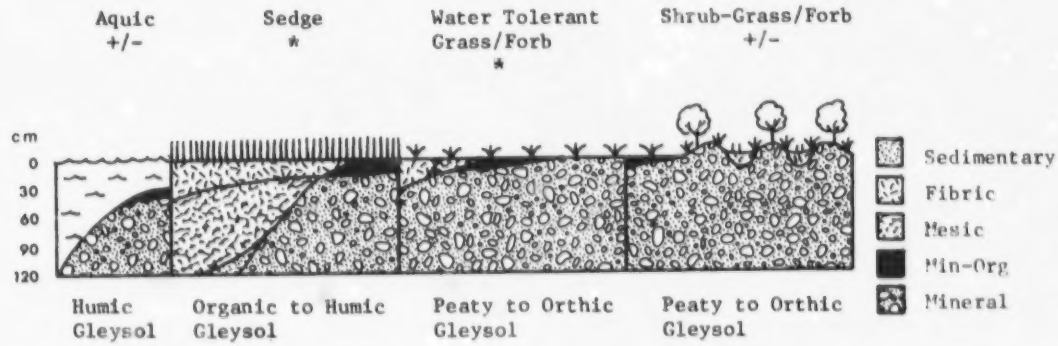
The Anahim Lake system must have a horsetail dominated component on sedimentary organic deposits (over at least 20% of the wetland area). A floating or supersaturated moss dominated component can not be present otherwise the system is classified as Nazko Lake.

CHILANKO FORKS SYSTEM

Sequence 1



Sequence 2



Description

The Chilanko Forks system is a compound wetland type. It shows characteristics of both the Stum Lake and Ragan Lake systems. Two diagnostic vegetation sequences are present. Sequence 1 is a sedge dominated vegetation component occurring on soils which may range from deep organics to organic matter rich mineral soils bounded by a shrub dominated vegetation component. If the component is a shrub-sedge cover type, soils will range from deep organic to Humic Gleysols. If the component is a shrub-grass/forb cover type, soils will range from smooth Humic Gleysols to mounded soils with mineral mounds and shallow peaty deposits in the depressions. Sequence 2 differs from Sequence 1 in having a sedge to water tolerant grass/forb vegetation sequence. The shrub-sedge component will be missing and the shrub-grass/forb component, if present, will lie on the margin of the wetland. Soils associated with components common to Sequence 1 are the same in Sequence 2 but the water tolerant grass/forb unit occurs on soils ranging from shallow peaty Gleysols to poorly drained mineral soils.

Associated Characteristics

It appears from our limited data set that Chilanko Forks systems associated with rivers are shallow organic systems with a high degree of interspersion whereas Chilanko Forks systems associated with shallow basins are more frequently deeper organic deposits (associated with the sedge component) and show low interspersion. Cattail and bulrush vegetation components, if present, indicate areas of permanent or near permanent inundation.

Diagnostic Characteristics

The presence of two vegetation sequences is diagnostic of a Chilanko Forks system. A sedge dominated to shrub dominated sequence and a sedge dominated to water tolerant grass/forb dominated sequence must both be present.

ANTHILL SYSTEM

Description

The Anthill system is characterized by a single component. A shrub and grass/forb dominated cover type occurs on soils which are frequently saturated to within 50 cm of the surface. The surface may show significant organic matter enrichment but this is frequently disrupted by ant-mounding.

Associated Characteristics

There is little or no evidence to indicate inundation of these systems. The frequent occurrence of ant mounds would indicate that these systems rarely if ever flood. They are included here only because the diagnostic component is often transitional from wetlands to uplands.

Diagnostic Characteristics

The shrub and grass/forb component is the only one which can occur in an Anthill system.

APPENDIX 4: COMMON NAMES WITH THEIR SCIENTIFIC EQUIVALENT FOR ALL PLANTS CITED IN THE TEXT.

All species referred to by a general common name (bracketed) are included. Common names are in alphabetical order.

Common Name	Scientific Name
Arrowgrass	Triglochin maritima
Birch	Betula glandulosa
Buckbean	Menyanthes trifoliata
Bulrush	Scirpus lacustris
Cattail	Typha latifolia
Cotton-grass	Eriophorum spp.
Dandelion	Taraxacum officinale
(Emergent grasses)	Glyceria spp., Alopecurus aequalis Beckmannia syzigachne Scolochloa festucacea
Fox-tail barley	Hordeum jubatum
Horsetail	Equisetum fluviatile
Moss	Drepanocladus spp.
(Sedge)	Carex atherodes C. aquatilis C. rostrata
Spike-rush	Eleocharis palustris
(Willow)	Salix spp. (includes Salix brachycarpa, S. glauca, S. maccalliana and S. pedicellaris)
Woolly-fruited sedge	Carex lasiocarpa

SUMMARY OF THE TECHNIQUES USED IN THE INVENTORY OF THE PEATLANDS OF NEW BRUNSWICK, CANADA

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ABSTRACT

The New Brunswick Department of Natural Resources has completed a detailed assessment of the peatlands of the Province. All peatlands exceeding 25 hectares have been investigated with the exception of those within the boundaries of National Parks and military bases.

An airphoto study was followed by the field investigation of 21,000 sites between 1975 and 1981. The methods used are similar to those of the Geological Survey of Finland. Investigation sites were established at 100 m intervals along grid lines. The elevation of each site was determined. A sample core was recovered at each site using a Hiller auger. The botanical constituents and the decomposition (according to the von Post scale) of each interval were determined. Surface vegetation, bottom sediment, and other factors were also recorded at each site. One or two representative sites were selected on most major peatlands for determination of several physical and chemical characteristics. The peat type and decomposition of each sample was recorded to enable grouping of results. The determinations made are dependent on the utilization potential of the site.

Calculations were performed with the aid of a computer. Information can be retrieved at the site, bog, and regional levels. Over 600 variables can be used as grouping parameters at the regional level. Contoured peat isopach and elevation maps are produced for each peatland. Cross-sections (profiles) displaying peat type and decomposition are drawn for each grid line. The inventory supplies multi-use information which enables assessment of utilization options by various disciplines and provides the basis for development of a long term resource management plan.

RÉSUMÉ

Le Ministère des Ressources Naturelles du Nouveau-Brunswick vient d'achever une évaluation détaillée des tourbières du Nouveau-Brunswick. Toutes les tourbières de plus de 25 hectares furent examinées sauf celles situées à l'intérieur des limites des Parcs Nationaux et des bases militaires.

Suivant une étude des photographies aériennes, 21,000 stations furent examinées entre 1975 et 1981. Les méthodes utilisées sont semblables à celles de la Commission Géologique de Finlande. Les stations d'investigation furent établies à des intervalles de 100 m le long des lignes d'inventaires. L'élévation de chaque station fut déterminée. Une carotte d'échantillons fut extraite à chaque station à l'aide d'une tarière Hiller. Les constituants botaniques et la décomposition (suivant l'échelle von Post) de chaque intervalle furent déterminés. La végétation de surface, les sédiments du fond et autres facteurs furent aussi relevés. Sur la plupart des tourbières d'importance, un ou deux emplacements représentatifs furent choisis pour la détermination de nombreuses caractéristiques physiques et chimiques. Le type de tourbe et la décomposition de chaque échantillon furent enregistrés afin de pouvoir grouper les résultats. Les déterminations effectuées dépendent du potentiel d'utilisation de l'emplacement.

Les calculs furent exécutés à l'aide d'un ordinateur. Les informations peuvent être recouvrées au niveau régional, de tourbière, et de station. Plus de 600 variables peuvent être utilisées comme paramètre de groupe au niveau régional. Des cartes de contours de profondeur de la tourbe et d'élévation sont produites pour chaque tourbière. Des sections croisées (profiles), exposant le type de tourbe et la décomposition, sont tracées pour chaque ligne d'inventaire. La multitude d'information disponible, résultant de cet inventaire, est d'une aide considérable pour un meilleur choix d'usage au niveau horticultural, agricole et forestier, etc., et procure la base du plan d'aménagement d'une ressource à long terme.

INTRODUCTION

The mining of peat moss on a commercial scale was reported in New Brunswick as early as 1894 (Ganong 1897). Eighteen peatlands owned by the Province are currently leased to twelve companies for the production of horticultural peat moss and related products. Some of the existing companies have been in continuous operation since 1942. Approximately four million standard bales of peat moss are extracted annually. This utilization, combined with increasing interest in the use of peat as a fuel, led to the realization that effective long term management of the resource required an improved knowledge of the extent and nature of the Province's peatlands.

Various researchers have published assessments of selected deposits (Ganong 1897; Anrep 1917, 1918, 1923, 1925; Leverin 1947) or descriptions of the development history and regional features of the resource (Auer 1930; Damman 1977, 1979; Korpijaakko 1975; Korpijaakko 1976; Langmaid 1962). However, a comprehensive evaluation of the entire province had never been attempted. As the first phase of such an evaluation, Airphoto Analysis Associates (1975) were contracted, during 1974, to locate and classify the peatlands on the basis of surface vegetation. Detailed field investigations were then carried out between 1975 and 1981. This paper describes the methods used in this assessment and outlines the procedures for data compilation.

SURVEY METHODS

The peatland inventory techniques used by the Geological Survey of Finland (Lappalainen 1979; Lappalainen *et al.* 1978) have been modified for use in New Brunswick (Korpijaakko and Pheeney 1977). An exchange program from 1977 to 1980 brought experienced geologists from Finland to the Province to train field staff. Each year one Canadian worked in the field with the Geological Survey of Finland. The exchange program made a significant contribution to the quality standards of the project.

Preparation

Aerial photographs at the scale of 1:20,000 were used in initial planning as well as for determining access and locating positions while in the field. To obtain the required photographs it was necessary to scan the coverage for the entire Province. This provided an opportunity to ensure the completeness of the study by Airphoto Associates (1975). They had assigned to each peatland an identification number. A number of additional peatlands that were not included in the study were recognized during the search of the photograph library. These were assigned the number of the nearest numbered peatland with a letter suffix. Thus, No. 999A is a peatland near No. 999 which was not identified in the initial study.

The aerial photographs for each peatland were examined using a mirror stereoscope to select the location of survey points. Figure 1 illustrates a typical pattern of survey points. No. 999 is an example of a peatland studied using a grid pattern while No. 999A was studied using traverse points. Size and potential of a peatland were determining factors in deciding which type of survey to use, but there was not a pre-assigned limit. Small peatlands in close proximity to other deposits were considered to have higher potential than one of the same size in an isolated location. In general, peatlands less than 100 hectares in size were not studied with a grid.

When planning the location of survey sites, the objective was to obtain the maximum amount of information with the minimum number of points. When domed areas could be recognized on the photographs the grid lines were planned to cross the areas which appeared to have thickest peat layers. When possible, heavily treed or ponded areas were avoided to minimize linecutting difficulties. Since the planning phase was done on an annual basis, the experience gained during each year's field phase could be drawn upon during subsequent planning.

Linecutting

Brush hooks with a long hooked blade were found to be an effective tool for linecutting. Topofil measuring instruments which reel out a disposable thread were used to chain distance. The topofil enabled one person to chain with good accuracy and were particularly advantageous on open peatlands. Pickets were placed at 100 m intervals along the grid lines. Most linecutting was carried out during the summer months in conjunction with the other phases of field work. However, it was found to be more efficient to cut lines in late fall when the frozen surface of the peatland gave improved walking conditions. When fall linecutting was conducted, pickets had to be solidly implanted, i.e. at least 50 cm, to ensure they did not float during the spring.

Each picket was numbered according to its distance (in metres) and direction (north, etc.) from the origin. The baseline was labelled as B, e.g. B 900N, and sidelines (usually perpendicular to the baseline) were labelled as L, e.g. L 900N+200E. On peatlands with more than one grid system (see Figure 1), subsequent line pairs were labelled F and G, H and I, etc. to

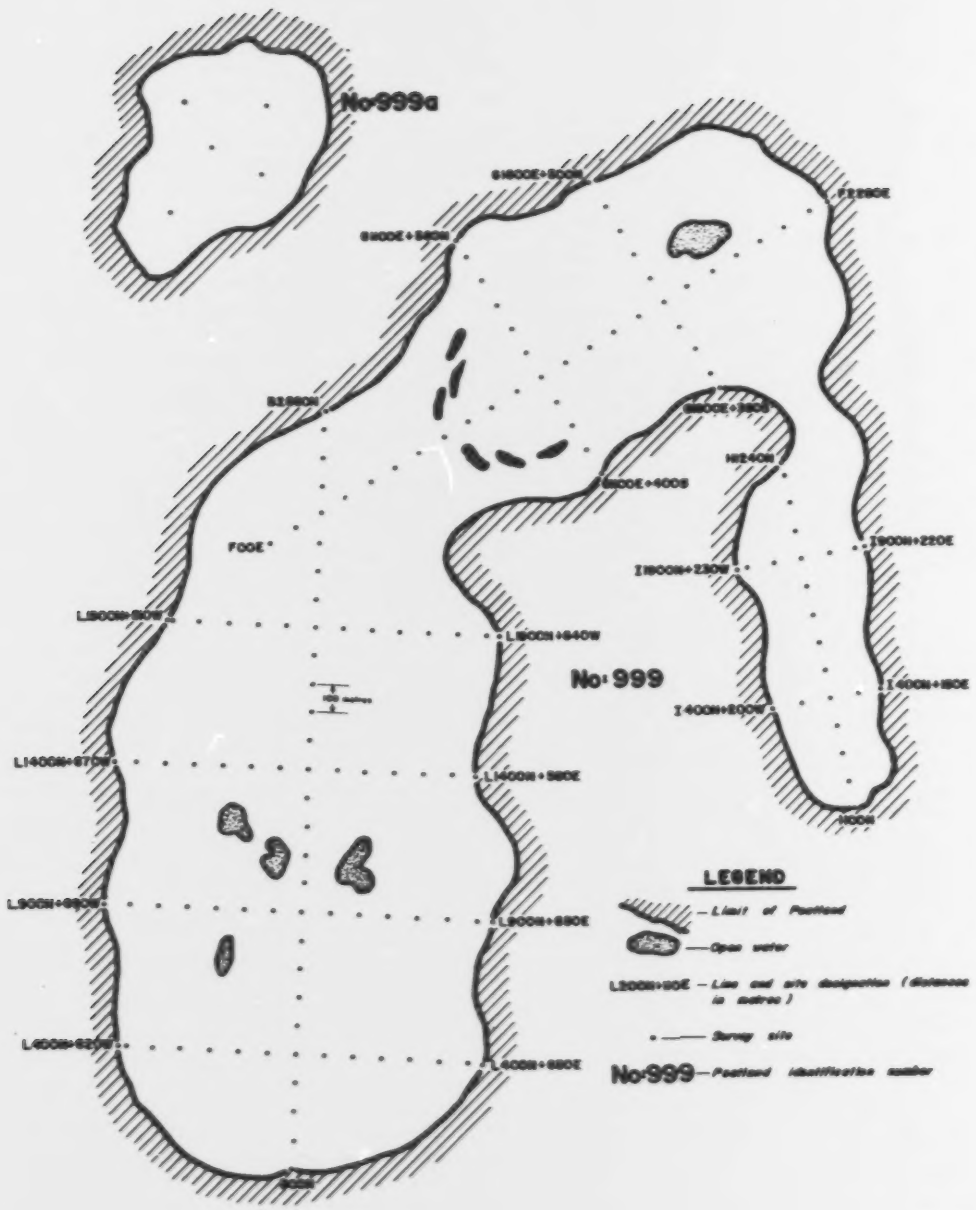


Figure 1: Typical survey pattern showing site number of the last point on each grid line.

facilitate computer data handling. Traverse points were given a T designation.

Grid lines ideally were cut until the margin of the peatland (i.e. mineral soil) was intersected. In practise, lines were terminated if peat depth was less than 1 m and dense cover was encountered, or if an extensive area of shallow (i.e. less than 1 m) peat occurred. Since these situations were difficult to predict from aerial photographs, the linecutters probed for the depth of peat and exercised their judgement. In some instances, traverse points were used to continue lines which were terminated due to dense cover.

Levelling

The elevation of each grid site was determined using self-compensating levels. Levelling rods with a bold "E" pattern (height of the "E" is 5 cm) gave the required accuracy and had good visibility in the high temperatures (i.e. heat waves) often encountered on the peatlands. Base stakes were driven at the intersection of grid lines and at the end of each line. These were used as control points when closing loops, etc. The elevation of major lakes, drainage channels, etc. was also determined.

The levelling grids were tied to survey monuments when drainage difficulties, such as the base of the deposit being below sea level, were anticipated. Where poor access, etc. precluded tieing to a survey monument the elevation of a reference site was estimated from topographic maps (normally Land Registration and Information Service orthophoto maps) and the elevation of other sites was determined relative to the reference point. The elevation of traverse points was not determined.

Drilling

At each site a Hiller auger was used to retrieve a top to bottom core in 50 cm increments. A standard data page (Figure 2) was completed for each site. Each line on the data sheet represents one 80 column card for computer input. Bog No. and Site No. comprise columns 3 to 20 and are common to all cards. The data page is divided into two parts: (1) the site card (S1) includes the elevation, cover type, no. of snags, sediment type, surficial depth, calculation flag, and number of intervals; (2) the interval card (C1, etc.) includes the depth of the interval, the peat type, humification, wetness, fine and coarse fibres, wood remnants and remarks. One interval card was completed for each division made in the sample recovered. Each section of the data page is discussed in detail below.

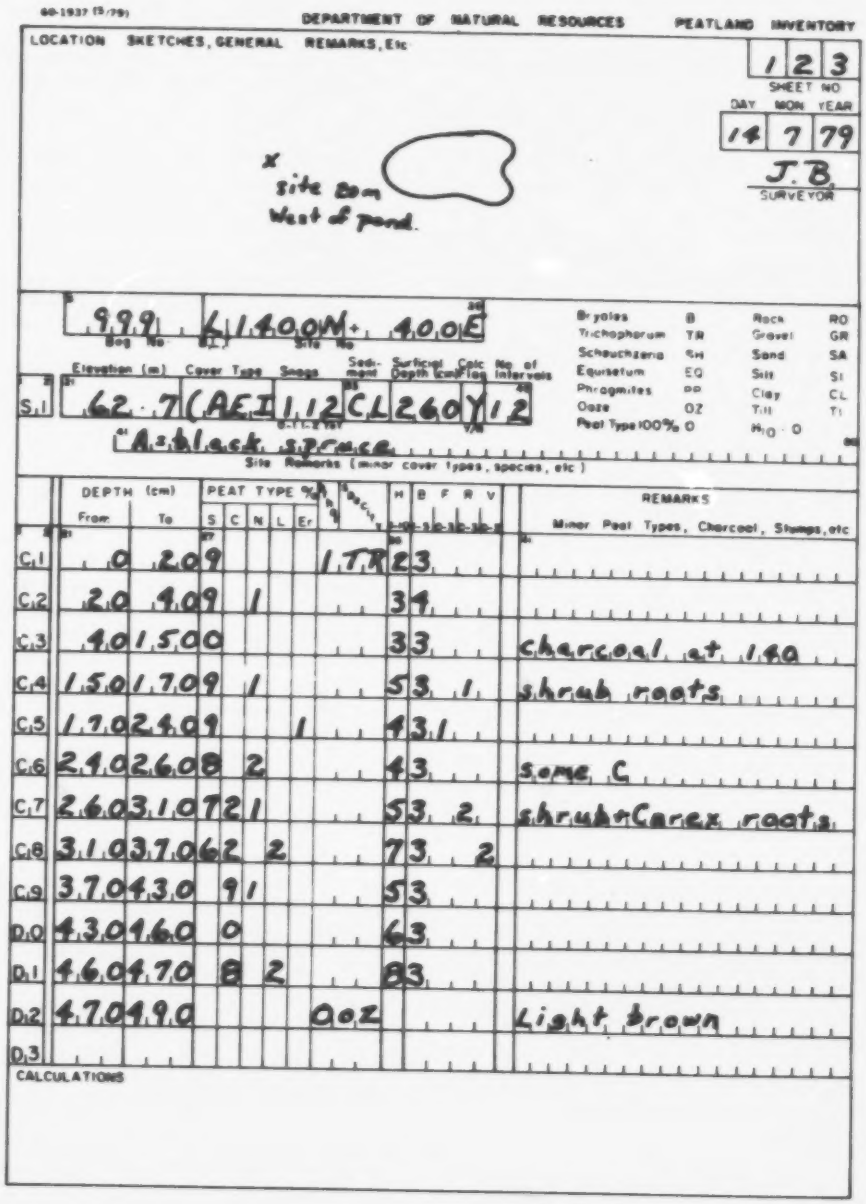
Bog No. - This is the identification number mentioned previously. While this identification number should properly be termed "peatland number", the initial years of field work were primarily on bogs. Hence, the term bog number gained common usage and was retained.

Site No. - Figure 1 shows a typical grid layout and gives the site designation for the end site of each line. The numbering system for sites has been previously described under the section headed "Linecutting".

Cover Type - Cover type (surface vegetation) was recorded using the nine pure cover classes shown in Table 1 (Radforth 1952). Any combination of up to three letters constitutes a cover formula for that site. The method used in New Brunswick for determining the formula is a modification of that described by Radforth. The nine classes were divided into three groups on the basis of height and growth habit: (1) tree cover (A and B); (2) intermediate layer (C to F); and (3) surface mat (G to I). The field investigator makes a visual estimate of the vegetation in the vicinity of the survey site and records one letter for each of the three groups (in order of decreasing height) if all groups are present. For example, an AEI formula could comprise a cover of tall spruce, low shrubs, and moss. The original system of Radforth did not include classes which constituted less than 25 percent of the total cover. In the New Brunswick system a class comprising 15 to 25 percent was recorded as a bracketed letter. For computerization purposes, a left hand bracket only was placed immediately in front of the class. Thus, the example shown in Figure 2 describes a cover of 15 to 25 percent class A and over 25 percent of both E and I. The inclusion of cover classes of less than 25 percent is particularly significant in the case of A and B since these can be a deterrent to peat mining.

If each of the three groups of cover classes are not present only one or two letters need to be recorded. For example, an EI cover type could consist of shrubs and mosses in amounts greater than 25 percent. However, if a group is absent and one of the remaining groups has two classes exceeding 25 percent, three letters can be used to describe the formula. For example, an EFI cover type has all three classes present in amounts greater than 25 percent with a greater amount of F than E. Cover classes present in minor amounts can be noted in the remarks.

The Radforth cover classes do not identify species, bog type, or trophy level. However,



60-1937 (5/79) DEPARTMENT OF NATURAL RESOURCES PEATLAND INVENTORY

LOCATION SKETCHES, GENERAL REMARKS, Etc

1 2 3 SHEET NO

DAY 14 MON 7 YEAR 79

J.B. SURVEYOR

x site 80m West of pond.

999 / 1400N + 400E

Bryales B Rock RO
Trichopharum TR Gravel GR
Scheuchzeria SH Sand SA
Equisetum EQ Silt SI
Phragmites PP Clay CL
Ooze OZ Till TI
Peat Type 100% O H_2O O

Elevation (m) 62.7 | Cover Types (AE) | Swags 1 | Sed-iment 1 | Surficial Depth 2 | Calc 60 | Flag Y | No. of Intervals 12

S,1

"A=black spruce

Site Remarks (minor cover types, species, etc.)

	DEPTH (cm) From	To	PEAT TYPE % S	C	N	L	Er	Bs	Bc	H	B	F	R	V	REMARKS Minor Peat Types, Charcoal, Stumps, etc
C,1	0	20	9					1	TR	2	3				
C,2	20	40	9		1					3	4				
C,3	40	150	0							3	3				charcoal at 140
C,4	150	170	9		1					5	3	1			shrub roots
C,5	170	240	9				1			4	3	1			
C,6	240	260	8	2						4	3				some C
C,7	260	310	7	2	1					5	3	2			shrub+Carex roots
C,8	310	370	6	2		2				7	3	2			
C,9	370	430	9	1						5	3				
D,0	430	460	0							6	3				
D,1	460	470	8	2						8	3				
D,2	470	490						OOZ							Light brown
D,3															

CALCULATIONS

Figure 2: Field data form with typical information (actual size is 8½" x 11").

Table 1: The properties of the nine pure coverage types of the Radforth Cover Classification (Radforth 1952).

Coverage type	Woodiness vs non-woodiness	Stature (approx. height)	Texture (where required)	Growth habit	Example
A	woody	15 ft. or over		tree form	Spruce, Larch
B	woody	5 to 15 ft.		young or dwarfed tree or bush	Spruce, Larch, Willow, Birch
C	non-woody	2 to 5 ft.		tall grass-like	Grasses
D	woody	2 to 5 ft.		tall shrub or very dwarfed tree	Willow, Birch, Labrador tea
E	woody	up to 2 ft.		low shrub	Blueberry, Laurel
F	non-woody	up to 2 ft.		mats, clumps, or patches, sometimes touching	Sedges, Grasses
G	non-woody	up to 2 ft.		single or loose association	Orchid, Pitcher plant
H	non-woody	up to 4 in.	leathery	mostly continuous mats	Lichens
I	non-woody	up to 4 in	soft or velvety	often continuous mats, sometimes in hummocks	Mosses

in New Brunswick the number of species comprising a particular class was relatively low. Anomalous situations were recorded in the remarks. For example, cover class A was normally spruce or tamarack so the presence of pine was noted in the remarks. Species which are good indicators of the trophy level of the peatland were also noted.

Snags - The term snags refers to stumps and wood remnants contained in the peat layer. A steel probe was inserted into the peat layer to a depth of 2 m. If the probe intersected a stump (i.e. was snagged) and could not penetrate the peat layer, then a snag was recorded for that probe location and a new location probed. Normally ten probes (including the two auger holes) were made at each survey site. Thus, total snags at a site is a function of ten probes. Total snags is subdivided into those between 0 and 1 m depth and 1 and 2 m depth. The example given in Figure 2 indicates one snag in each layer, so that two of the ten probes were "hits". The number of snags intersected is used to estimate the volume of wood in a peatland. As well, the number of intersections can be used to make relative comparisons between peatlands.

Sediment - The nature of the sediment underlying the peat layer was recorded using the letter codes shown in Figure 2. The augers used in the field survey did not penetrate well into the sediment. Thus identification was often made on a small amount of sample.

Surficial Depth - A poorly decomposed peat comprised primarily of Sphagnum is considered a top quality horticultural peat. The term surficial depth refers to the thickness of the upper strata of a peat deposit (i.e. surficial layer) with humification of H1 to H4. While the surficial depth often corresponds to the thickness of horticultural grade peat, the botanical composition must also be suitable.

The surficial depth was recorded at the conclusion of the drilling at each site. The boundary between the surficial layer and humified layer was determined by examining the humification of each interval. The depth at which the change between surficial peat and humified peat occurs was recorded. Thin layers of well humified peat can be included within the surficial layer, such as the C4 interval in Figure 2.

Calculation Flag - Occasionally a depth probe was made at a site but a description of the peat was not. Since the computer would treat the missing values as zero it was not desirable to include such a site in the detailed calculations. Thus, an "N" under calculation flag excluded the site from calculations.

No. of Intervals - The sample recovered by the Hiller auger was divided into intervals based on changes in peat type and decomposition. One line on the lower part of the field sheet was used for each interval. The number of intervals was recorded on the S1 card and used as an internal check during input of data on the computer.

Depth - The surface of the peatland at each site was considered zero depth. The thickness of each interval was recorded in centimetres. However, the intervals were normally divided to the nearest 10 cm.

Peat Type - Each interval was examined to determine the botanical composition. The composition was estimated to the nearest 10 percent and recorded. For convenience, 100 percent was recorded as zero, 90 percent as nine, 80 percent as eight, etc.

The most common peat types form the first columns; the percentages of S (Sphagnum), C (Carex), N (shrubs), L (wood), and ER (Eriophorum) were recorded in the appropriate columns. When the botanical composition included additional constituents the percentage was recorded under "other". If "other" was composed of only one species it was identified under "specify" according to the codes given on the top right of the data page. If "other" was composed of more than one species the code MS (miscellaneous) was recorded and the species identified in the remarks. Botanical constituents present in minor (less than 10 percent) amounts were also noted in the remarks.

While identification of the plant remains in poorly decomposed peats was relatively easy, the process became more difficult with increased decomposition. Each peat sample was first examined to determine which of the three dominant peat groups formed the major portion. Thus, a sample was either Sphagnum-dominated, sedge (Carex)-dominated, or Bryales-dominated. The minor constituents were then identified and the percentages estimated. When describing a particular peat the dominant peat type is noted last. Thus, a shrubby-Carex-Sphagnum peat (NCS) is composed predominantly of Sphagnum with lesser amounts of Carex and shrubs.

The term "ooze" is used to describe subaqueous humus and includes dy, gyttja, muck, sapropel, and sedimentary peat as defined by Stanek (1977). The material is commonly amorphous and can occur as a gel. Colour ranges from light green to light brown to grey to black. The inorganic content varies considerably depending on the environment of deposition. Ooze is normally found in the basal layer of the deposit although it occasionally occurs higher in the sequence in peatlands associated with streams.

Humification (H) - The state of decomposition or degree of humification was recorded according to the von Post scale. The ten degrees of the scale are described in other publications (Korpijaakko and Pheeney 1977; Korpijaakko and Woolnough 1977). The number of the scale is recorded for each interval on the field form. Humification 10 is indicated as zero.

It should be noted the von Post method is designed for field use in undrained peatlands. The "squeeze test" to determine degree of humification is performed only after releasing free water by firmly pressing the sample between "cupped" hands. The results of the squeeze test should be considered in conjunction with the amount of recognizable plant structure, amount of amorphous material, and the amount and colour of water released.

Wetness (B) - This is a relative estimate of the moisture of the interval. The scale ranges from 1 to 5 with 3 being normal. One is dry while 5 is very wet. A high value for B often indicates poor sample recovery, i.e. the sample was mainly water.

Fine Fibre (F), Coarse Fibre (R), and Woody Remnants (V) - All of these scales range from 0 (nil) to 3 (high). A value greater than zero should also be evident in the peat type. Fine fibre is typically "root hairs" from species such as Eriophorum (the species responsible would be identifiable under peat type). Coarse fibres are commonly rootlets from Carex or shrubs. The species would be identifiable under peat type and was often noted in the remarks also as shown in interval C8 of Figure 2. Woody remnants would be reflected by wood (L) in the peat type. Because of the strong relationship of these factors to peat type, they received little emphasis

during the data compilation phase.

Remarks - This section was used to record various parameters which did not readily fit any of the previous columns for each interval. Peat types which comprised less than 10 percent, seeds, charcoal layers, etc. were recorded under remarks.

Wildlife

During the course of the inventory, it became evident that there was little information available on the use of the Province's peatlands by various wildlife species. For this reason, all field crews recorded wildlife sightings during the last three years of the project. When possible, the species, sex, maturity, and habitat use of each sighting was recorded. The information compiled could not truly be classed as a wildlife survey. However, some trends were recognizable and should provide an indication of the approach required if a detailed study becomes necessary.

SAMPLING FOR PHYSICAL AND CHEMICAL ANALYSIS

Using the data recorded on the field sheets, completed field maps, and if available, the profiles for each peatland, one or two representative sites on most major peatlands were selected for follow-up sampling. The sites were divided into two types: those with good fuel peat potential and those with low fuel potential. Both types were well distributed across the Province to ensure that various peatland types, as well as bedrock types and climatic zones, were represented in the samples.

The objective of the sampling program was to evaluate the physical and chemical properties of the peats to determine if significant variation existed in these properties that would have an influence on the suitability of the peat for various end uses. While the evaluation of the fuel value of the peat was a major consideration in the sampling, a data bank of the levels of various metals and other parameters could easily be determined on the same samples with relatively no additional cost. Thus, the aim of the program was the accumulation of data rather than the investigation of a specific problem. However, the compiled information identifies various trends and relationships which warrant detailed studies by researchers.

From 1977 to 1979 the samples were collected using a 5 cm diameter piston sampler which recovers a sample up to 80 cm long. During 1980 and 1981 a 10 cm diameter MacCauley sampler (also called Russian sampler) was used to recover 50 cm long samples. These and other samplers have been described by various authors (Lappalainen 1978; Tolonen 1967; Day *et al.* 1979). The piston sampler was suitable for most applications. However, some difficulties were encountered with compaction of the sample which was problematic in the determination of bulk density. The MacCauley sampler minimized this problem. As well, it was somewhat faster to operate in most peat types with the exception of woody peats and matted sedge layers. A modified 10 cm piston sampler (Korpijaakko 1981) has been used in Finland for bulk density determinations with good results. However, the sampler recovers a sample only 20 cm long. In most instances, all of these samplers are unsuitable for sampling the surface layers of the peatland. While "stove-pipe" type samplers can be used for this layer, a long knife or brush hook was used in New Brunswick.

The collection and subdivision of samples at the selected site was performed in much the same manner as described previously in the section on "Drilling". Division into intervals was made on the basis of changes in peat type and botanical composition. The depth of each interval was recorded. When using the MacCauley sampler only one-quarter diameter sample was retained. The second quarter was used to classify the intervals. When using the piston sampler this classification was achieved using a second core or by using a Hiller auger. Each sample was sealed in plastic to avoid moisture loss during transportation to the laboratory. The bedrock type, cover vegetation, depth code (surface - intermediate - basal), and coastal/inland relationships were also noted for each sample. These parameters are used as grouping parameters when interpreting trends in the results.

At sites with low potential for fuel peat, a single sample core was recovered. Moisture content and, in the last three years of the program, bulk density were determined on each sample. An acid extract of the peat was analyzed for Na, K, Ca, Mg, Fe, Mn, Cu, Pb, Zn, Ni, and on selected samples, U, P, B, C, Cl, V, and S. Results were reported on a dry peat basis.

At the second type of site, analysis of the peat ash is performed. In order to obtain sufficient sample for this and the other determinations, two sample cores were recovered at each site. Again, moisture content and, in later years, bulk density were determined on each sample. The double sample core enabled replicate determinations of moisture content and bulk density to be made. One sample was then used for the determination of calorific value, sulphur and volatiles, and on selected samples, ash melting point, carbon, total and

available nitrogen and phosphorus, chloride, and ultimate analysis (C, H, N, and O). The second sample was used for determination of ash content and the ash was analyzed for Fe, Mn, Na, Ni, Pb, Zn, K, and Cu, and for selected samples, Al, B, Ca, Mo, Mg, Si, and U.

The results obtained, in addition to their value in evaluating the properties of the peat, are also useful in biogeochemical prospecting and the monitoring of the rate of deposition of airborne pollutants.

DATA COMPILATION

Orthophoto maps at 1:10,000 scale were used to prepare base maps. The location of the grid network and survey site was plotted on the base map. The extent (or limit) of the peatland was plotted based on interpretation of aerial photographs and the field data. The resulting base map is similar to Figure 1. In most cases, the plotting of peat isopach and elevation maps on copies of the base map was completed on a daily basis while in the field. Each was contoured on one metre intervals.

A depth of one metre is generally considered the limit of economic mineability of peat. For this reason, special care was taken in the establishment of the one metre contour on the peat isopach maps. Drilling crews often completed depth probes between survey points to accurately establish the location of the one metre contour. While the isopach contours were based on total peat depth (excluding ooze), the depth of the surficial layer at each site was also noted on the map. As well, the weighted average of the humification of each site was noted so that sites could be rapidly compared without referring to the field data.

Each of the three maps is later drafted using a standard legend and format. The standard map size is 24 in. by 34 in. (including 8 in. legend) and covers three seconds of latitude and five seconds of longitude. Approximately 290 map sets will be available at the completion of the project.

Using the completed maps the total area of the peatland and the area where peat depth exceeds one metre were determined using a planimeter. The boundary of Crown and private lands was also plotted and the areas of each of the peatlands measured. If the peatland was leased, the area of the lease, area in production, etc. were also determined.

These areas, as well as location information, survey statistics, and other factors were compiled for each peatland and combined with the field data sheets for computer input.

Computer Processing

The compiled data was keypunched and entered into the computer. The data was checked, both visually and by the computer, for errors which occurred during the transfer of data. The average humification (weighted by depth) for the surficial layer, humified layer and combined thickness of each site was then determined. This information plus the data recorded on the field sheets constitute site level data and can be retrieved as such in a standard format.

The site level data was combined with information such as areas and locations, and numerous calculations were performed. A total of 25 tables are available at the bog level. Only a brief summary can be presented here.

The distinction between surficial layer (H1 to H4) and humified layer (H5 to H10) has previously been discussed. Most calculations are performed for each of these layers plus the combination of the two. Only sites with a depth of one metre or more are included in the detailed calculations. It was found that in most cases the number of sites with depths less than a metre was not large enough to provide a reliable average for calculation. In instances where it was necessary to perform calculations for the entire peatland, such as the total volume, the calculation was performed using the area and sites with one metre depth. The value obtained was totalled with a similar calculation for a portion of the peatland with depths less than one metre. An average depth of 0.5 m was assumed for the portion less than one metre in depth.

A computerized summary of the detailed bog level tables for each peatland is subdivided on the basis of the surficial, humified, and combined layers and includes the following:

Average depth and humification

Percentage and volume of 22 peat types

Percentage and volume of 3 dominant peat groups (Sphagnum, Sedge, and Bryales)

Average humification of 22 peat types

Percentage and volumes of layers where minor peat types (shrubs, wood, Eriophorum, etc.) exceed 10 percent

Percentage of snags

Percentage and volume of 10 degrees of

humification.

In addition, a two page summary report is produced and is illustrated in Tables 2 and 3.

Bog level output is the summary of a number of sites on a particular peatland. Similarly, regional level output is a summary of a number of peatlands in a specified group. The same tables as those listed above are available at the regional level. The information shown in Tables 2 and 3 is on a different format at the regional level but contains essentially the same data.

Over 600 variables can be used in combination to group peatlands at the regional level. For example, if a peatland with an area larger than 200 hectares containing a volume of over one million cubic metres of pure Sphagnum peat with humification less than H4 is required, the computer will provide a regional level output of all peatlands meeting these criteria.

Compilation, calculation, and statistical treatment of all analysis data is also done with the aid of the computer. As well, the time consuming process of drawing profiles (cross-sections) along each grid line is carried out by the computer.

Table 2: Page one of the summary report produced for each peatland

BOG NO.: 999

PEATLAND MAP NO.: J99 NAME: Jones Heath

NTS NO.: 21 J/11 COUNTY: Carleton

LATITUDE: 463918 LONGITUDE: 671125

PEATLAND TYPE: Ombrotrophic TREE COVER: 20%

LOCATION AND ACCESS: 5 km west of Dogpatch Jct. Access by bush road from route 99.

STATUS OF EXPLOITATION: Virgin

LEASED TO:

OWNERSHIP AND LEASE DATA
(All Areas in Hectares)

	CROWN	PRIVATE	TOTAL
Total area of peatland	472	28	500
Area with depth exceeding 1 m	420	20	440
Area in production	...	...	...
Area abandoned:	...	...	...

Total area of lease: -

Lease area with depth exceeding 1 m -

Table 3. Page two of the summary report produced for each peatland

BOG NO. 999

SURVEY TYPE: Grid STUDIED: July 1979

LENGTH OF GRIDLINES: 13.8 km SURVEYOR: J.B.

NO. OF POINTS: 149

NO. OF LINES: 11 MAXIMUM DEPTH: 62.0 DM

MAXIMUM ELEVATION: 102.7 m

	Entire peatland	Portion with depth exceeding 1 m
Area (hectares)	500	440
Average depth (dm):		
Surficial:	23.5	24.2
Humified:	14.7	15.2
Overall:	38.2	39.4
Average humification:		
Surficial:	3.1	3.1
Humified:	5.2	5.2
Overall:	4.3	4.3
Volume (million cubic metres):		
Surficial:		10.65
Humified:		6.69
Overall:	17.64	17.34

Stump content: 0.62%

Two profiles are produced for each line. One shows the distribution of humification while the second displays peat type distribution, cover types, bottom sediment and snags. The computer plots the profiles in ink on drafting plastic and completes all lettering. Since some interpretation is required to outline the various layers and lenses of peat types and humification degrees, this is completed manually. Symbols are then added using letratone.

The computerized data handling system was developed specifically for the project. The software development included standard library packages where possible. The programs are in a modular format with numerous subroutines to facilitate modification. All data processing was carried out using the facilities of the University of New Brunswick computing centre.

Report Format

Annual open file reports (Korpijaakko 1977; Korpijaakko and Pheeney 1976; Keys 1978, 1979; Keys *et al.* 1980) were compiled at the conclusion of each year's field work. Some were completed prior to the use of computers and do not contain the detailed calculations currently available. These open file reports are being revised and updated with the information recompiled on the basis of 1:250,000 scale N.T.S. map sheets.

While all the information discussed in this manuscript is available to the public, the material available for general distribution consists of the 1:10,000 scale base, isopach, and elevation maps and the summary reports illustrated in Tables 2 and 3. The summary reports for each peatland are supplemented by a written description of the general characteristics of the peatland, the distribution of peat types and humifications, surface vegetation, drainage characteristics, recommendations for potential use, and a summary of analysis information.

General reports on peatland zones and vegetation, peat quantities and qualities, survey methods, computer methods, and chemical analysis will also be compiled.

APPLICATION OF THE DATA

The survey methods used in New Brunswick provide three-dimensional, multi-use information at a relatively low cost. The compiled information can be used: to assess the potential of extraction of peat for horticultural or fuel purposes; to select sites for "in situ" uses, such as agriculture, forestry, wildlife habitats, and conservation; for engineering studies; and for academic research.

With regard to peat extraction, the quantities identified must be regarded as "in situ" or resource values. The recoverable reserves are substantially less but can be estimated with reasonable confidence by detailed examination of the compiled data.

An average density of one site per 6.4 hectares was attained in the inventory. Naturally an increased site density would allow greater confidence in the survey results but would be difficult to justify in a regional survey. However, it should be recognized that, in most instances, it would be advisable to supplement the data with additional depth probes and elevation readings before attempting to drain or develop a particular peatland.

The chemical data can be used to further define the suitability of a peatland for a specific use. In addition, the results can be used in biogeochemical prospecting.

New Brunswick is the first jurisdiction in North America to acquire such a detailed knowledge of the peat and peatland resources. Development and utilization of the resource is increasing and indicates the need for long term management of the resource. The inventory provides the basic information to develop an effective management plan.

ACKNOWLEDGEMENTS

The project was funded by the Canada Department of Regional Economic Expansion and the Province of New Brunswick under a number of Federal-Provincial Agreements. Dr. Eino Lappalainen and the staff of the Geological Survey of Finland are thanked for their participation in the exchange program and their frank discussions of inventory techniques. Software development and implementation in the data compilation phase was provided by Chary N. Kandalam. The author acknowledges the contributions of co-workers, particularly V. Klemetti, R.E. Henderson, R. Doiron, and D. Ferguson, in the collection and compilation of data. Much of the material presented here has been submitted for publication and is copyright ASTM, 1916 Race Street, Philadelphia, Pa 19103. It has been adapted for publication with permission.

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HUDSON BAY LOWLAND PEATLAND INVENTORY

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ABSTRACT

In 1976 a program of ecological studies in the HBL was initiated by Environment Canada. This paper summarizes the inventory information available on wetland and peatland types and on the peat resources in the HBL. The wetlands have been classified on the basis of vegetational physiognomy. This approach was found useful for integrating other soil and site information.

In the Ontario HBL the coastal, arctic tundra and subarctic vegetation units occupy 28.1% of the area; upland forests, rich swamps and white spruce 2.4%; fens and water 13.5% and the remaining 54.1% consists of muskeg and bog types.

The mapping of wetland ecosystem patterns using Landsat imagery has been undertaken by the Ontario Centre of Remote Sensing. The best form of Landsat data is the computer compatible type (CCT). The maps produced can be used for integrated investigations of peatlands. Also the same peatland ecosystem types identified on the maps could provide the basis for stratification of sampling for any number of biotic and abiotic conditions.

RÉSUMÉ

En 1976, Environnement Canada a lancé un programme d'études écologiques dans les basses terres de la baie d'Hudson. Cette communication résume les données d'inventaire disponibles sur les types de terres humides et de tourbières ainsi que sur les ressources en tourbe de ces basses terres. Les terres humides ont été classées selon leur faciès végétal, et nous avons remarqué que ce type de classification se prête à l'intégration d'autres renseignements sur les sols et les stations.

Dans la partie ontarienne des basses terres, les unités végétales côtières de la toundra arctique et subarctique occupent 28.1% de la superficie; les forêts des hautes terres, les marécages riches et l'épinette blanche, 2.4%; les tourbières minérotrophes et les plans d'eau, 13.5%; différents types de muskegs et de tourbières oligotrophes occupent les 54.1% qui restent.

Le Centre de télédétection de l'Ontario a entrepris de cartographier les écosystèmes de terres humides au moyen d'images Landsat, dont les meilleures sont celles qui sont utilisables sur des ordinateurs. Les cartes ainsi produites peuvent servir à des études intégrées des tourbières. En outre, les mêmes types d'écosystèmes de tourbières qui sont identifiés sur ces cartes peuvent servir de fondement à la stratification de l'échantillonnage d'un nombre indéterminé de conditions biotiques et abiotiques.

INTRODUCTION

In 1976 a program of ecological studies in the Hudson Bay Lowland (HBL) was begun by Environment Canada. This program continued over a five year period, and served to stimulate many other basic land and terrain studies by other agencies and universities. Many of these studies were reported recently in the Hudson/James Bay Symposium held in Guelph, April 1981.[1] A comprehensive summary of the accomplishments of the federal program is close to completion.[2]

The purpose of this paper is to summarize the inventory information available on wetland and peatland types, and on peat resources, in the HBL. The paper concentrates on four studies or mapping programs which have made major contributions to the inventory of wetlands and peat. One of these is a map of the vegetation patterns of the HBL produced prior to the federal program. Two of the studies evolved out of the federal program -- (i) an ecological land survey of the coastal zone, and (ii) a detailed ecological survey of wetlands in a restricted area in the interior of the southern HBL (Kinoje Lakes). The final topic deals with a mapping project, from satellite imagery, of the whole of the HBL.

THE STUDY AREA

The Hudson Bay Lowland is a 325 000 km^2 wetland complex located along the coasts of Hudson and James Bays (Figure 1). Approximately 260 000 km^2 lie within the province of Ontario. The Lowland is underlain by Paleozoic strata of the Hudson Platform. The strata are predominantly limestones, dolomites and sandstones of Ordovician, Silurian and Devonian ages (Sanford, Norris and Bostock 1968). Deglaciation in the area occurred approximately 7,000-8,000 years B.P. and since that time up to 150 m of isostatic uplift has occurred (Andrews 1969). Immediately following deglaciation the entire area was inundated by the Tyrrell Sea. The maximum level of marine inundation corresponds approximately with the southern and western boundaries of the Lowland. Organic deposits ranging in depth from 1-4 m overlie a gently sloping (0.5-1.0 m/km) marine plain. These deposits have created an extensive and unconfined wetland complex broken only by raised gravel beach ridges and by levees along major rivers. Uplift, which continues at a rate of 1-1.2 m/100 years (Webber, Richardson and Andrews 1970), results in a gradual but continuing expansion of the peatland over the emerging marine plain.

TERMINOLOGY

At the start of the HBL program it was decided to employ the wetland classification of Jeglum *et al.* (1974) in describing sites. This classification utilized the four main wetland units recommended by a national committee on wetlands (Zoltai *et al.* 1975) -- bog, fen, marsh and swamp. However, the Jeglum *et al.* classification diverges from the national approach in utilizing vegetational features to subdivide the main units in an hierarchical framework. The reason this was done was for ease of identification in the field, and to facilitate the interpretation of the wetland types from air photos and other remote sensing imagery.

As the HBL program developed, it turned out that the classification based on vegetational physiognomy was a useful way of organizing other site and soil information, because the vegetation is an excellent integrator of the main ecological factors influencing wetland variation, especially moisture regime and nutrient regime. As well, there are certain inferences that can be made concerning the underlying peat horizons -- their decomposition and botanical composition -- by knowing the physiognomic type of vegetation.

The physiognomic types that were recognized by Jeglum *et al.* (1974) had to be changed to accommodate new types that were found in the HBL. For example, lichen bog was a particularly conspicuous type on aerial photos and satellite images. Much less common types that were recognized in the HBL were bog pool moss mats and fen pool moss mats (Jeglum and Cowell, in press). In the HBL work, it was necessary for practical purposes to separate treed fen from swamp on the basis of dominance, the former being characterized mainly by tamarack and white cedar, the latter by black spruce or white spruce. Also, it was decided that the term 'swamp' would be used for spruce-dominated minerotrophic wetlands. When the spruce-dominated conditions became ombrotrophic, i.e. rain-nourished (groundwater with calcium < 2.0 ppm) the type would be regarded as bog (cf. Sjörs 1963).

VEGETATION PATTERNS OF THE HBL

Bates and Simkin (1969) produced a map of the vegetation patterns of the HBL, north of the 52nd parallel in Ontario. This eminated out of, but was a refinement and completion of,

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[1] Proceedings of this Symposium will be published in Volume 109 of the Naturaliste Canadien, 1982.

[2] Contact D. Cowell.

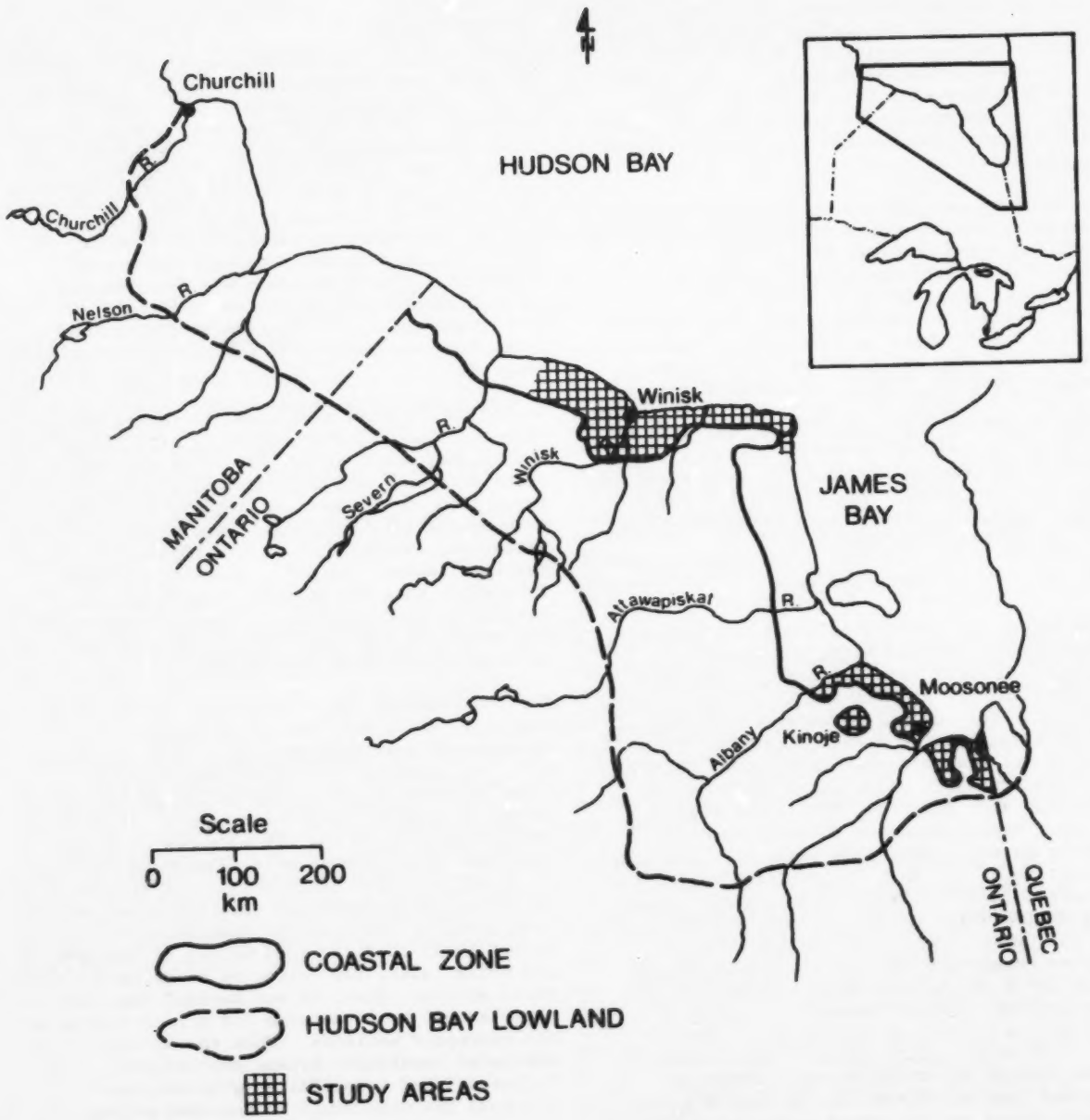

Figure 1: The Hudson Bay Lowland showing the coastal zone boundary and coastal and Kinoje study areas.

the work by Brokx which was concerned with caribou habitat (1965) and the types of peatland and vegetation (1967). The map is at a scale of 1:6,300,000 (approx.) and it has 96 mapping unit types, many of which are complexes of two or more of the 34 vegetation types.

Beach ridges were indicated by symbols which always overlaid other vegetation types. Lichen woodlands, and lichen woodlands and ridges, were represented as symbols which either overlaid other vegetation types, or occurred as pure units. The 'vegetation types' themselves were often complex types -- e.g. 'low palsa fen' and 'mixed forest, upland coniferous forest, rich swamp'.

To determine aerial extents of the vegetation types, each mapping unit was classified according to the dominant, first-named, type in it. A dot grid method was used to determine percentage cover of each vegetation type. The types were segregated into those occurring along the coast and the arctic tundra and subarctic types in the north, and those that are found mostly in the interior, and which are less permafrost influenced and more boreal in nature. Vegetation type varieties were combined with the other nonvarietal (basic) units. Some of the vegetation types were not first named in any of the map units. The aerial extents of the resulting 29 vegetation units (two of which were actually not vegetation -- 'water', and 'marsh' which were defined as frequently flooded land) are presented in Table 1.

Coastal, arctic tundra and subarctic types, as defined by Bates and Simkin (1969) occupy 28.1% of the Ontario HBL north of 52°N latitude. The more abundant types are sedge meadows, subarctic polygon muskeg, sinuous lichen muskeg, and round lichen muskeg. In current usage, the term 'salt marsh' is applied to many of the coastal flats with vegetation, and this would include many of the sedge meadows used in this map. Muskeg is used by these authors as treed muskeg. This is used, generally, for poor sites supporting stunted, slow-

Table 1: Areal coverage of vegetation and terrain patterns in the Hudson Bay Lowland north of the 52nd parallel in Ontario (from the map by Bates and Simkin 1969).[1]

% Coastal, Arctic Tundra and Subarctic Types		% Interior Types (Primarily)	
1. Lichen Woodlands	-1.2	16. Mixed Forest, Upland Coniferous Forest, Rich Swamp	-1.8
2. Lichen Woodland and Ridges	-1.4	17. White Spruce Forest	-0.6
3. Coastal Fens	-0.0[2]	18. Black Spruce Muskeg[3]	-12.9
4. Sedge Meadows	-3.1	19. Riparian Lichen Muskeg	-0.2
5. Forest Tundra	-1.8	20. Transitional Lichen Muskeg	-<0.1
6. Lichen Heath	-1.3	21. Spruce Island Muskeg	-11.7
7. Polygon Fen	-1.9	22. Bog Island Muskeg	-8.5
8. Low Palsa Fen	-1.9	23. Tamarack Fen	-8.8
9. Palsa Field	0.2	24. Tamarack Fen with Fen Pools	-1.0
10. Subarctic Polygon Muskeg[3]	-3.3	25. Spruce Island Fen	-4.0
11. Sinuous Lichen Muskeg	-5.4	26. Open Bog Forest on Revised Bogs	-14.4
12. Round Lichen Muskeg	-5.6	27. Wet Raised Bogs	-4.7
13. Palsa Bog	-0.2	28. Marsh[4]	-<0.1
14. Subarctic Raised Bog	-0.4	29. Water	-1.9
15. Subarctic Raised Bog with Numerous Pools	-0.4		70.5
	28.1		

[1]Mapping units were usually complexes of the 34 basic vegetation or terrain units. The mapping unit was classified according to the major, first-named component.

[2]Coastal fens were never a first named component.

[3]The term muskeg is used by the authors as treed muskeg. This is a peatland type with stunted, slow growing black spruce, with a low ericaceous shrub understory, and a fibric surface organic horizon with Sphagnum and feather mosses. The concept includes stands which may be either weakly minerotrophic (poor swamp) or ombrotrophic bog.

[4]The authors regarded marsh as 'frequently flooded land' and it was mapped for only a few interior locations.

growing black spruce, usually with relatively open canopies. The understory is dominated by low, ericaceous shrubs and there is a fibric surface organic horizon, with Sphagnum and feathermosses. The 'muskeg' concept includes weakly minerotrophic sites (poor swamp) and ombrotrophic treed bog (e.g. Jeglum 1972). The sites are elevated, by the development of the fibric horizon, above and out of the influence of mineral soil water, and they are usually flat or convex, raised landforms. The degree of isolation determines whether the site is still weakly minerotrophic or completely ombrotrophic (rain-nourished).

The remaining interior portion comprises over 70% of the Bates and Simkin map. Some of the more common types are black spruce muskeg, bog island muskeg, tamarack fen, and open bog forest on raised bogs. The combined units of upland forests, rich swamps and white spruce make up only 2.4%, and fens and water 13.5% of the 70%. The remaining 54.1% consists of the muskeg and bog types. Hence, peat development has progressed to the bog or close-to-bog stage in the majority of the HBL interior.

COASTAL ZONE STUDIES -- ENVIRONMENT CANADA

Although the primary purpose of this research program has been to develop a more comprehensive understanding of the habitats in the region and their relationship to the migratory bird resource, some of the information is of value to those concerned with the area as a potential source of peat for energy, agriculture or horticultural purposes (Wickware *et al.* 1980).

This zone was defined as that part of the Lowland characterized by a distinctive hydrologic, vegetative and physiographic regime, bordered on one side by the waters of Hudson and James Bays, and on the other by a more mature peatland complex (Cowell, Wickware and Sims 1978). The coastal zone, as defined, varies in width 1-60 km. It is characterized by two major climatic regimes. Along the Hudson Bay coast, permafrost occurs widely with patterns in the peatland complex reflecting this factor. Permafrost is not a major factor along the James Bay coast and peatland patterns are quite different from those along Hudson Bay.

Ecological Characteristics

Figures 2 and 3 represent idealized composite cross-sections through the coastal zone in each of the study areas. In southern James Bay (Figure 2) the gradient on the lowest or poorest drained sites ranges from the nutrient rich salt marsh, through freshwater marsh and fen complexes nearest the coast, to the nutrient-poor bog complexes of the interior. The soil gradient trends from saline Rego Gleysols[3] on the coast to Humic Gleysols in the freshwater marsh and fen complexes to mesisols and fibrisols in the deeper peat accumulations. Black spruce – balsam poplar feathermoss forest types occur on the better drained beach ridges with soils grading from regosols (nearest the coast) to podzols. On some of the more poorly-drained ridges (i.e. low ridges) alder-willow thicket types with Orthic Gleysols occur nearest the coast, and these grade through conifer swamps with Rego Gleysols into black spruce treed bog with Terric Fibrisols.

Along the Hudson Bay coast (Figure 3) the wetland gradient is once again from the nutrient rich salt marsh, freshwater marsh and fen complexes nearest the coast to the bog complexes of the interior. The presence of permafrost however results in a much different patterning. Brown moss and lichen-heath palsas dominate in many of the graminoid fen complexes, and polygon treed fen patterns replace the extensive and patternless treed fen found in southern James Bay. Ice-cored bog plateaus dominated by a black spruce lichen cover occur further inland. Well drained beach ridges grade from unvegetated on the coast to lichen-heath-low shrub types and lichen-heath ridges immediately inland. White spruce lichen and black spruce lichen woodland ridges replace the heath ridges and grade into black spruce lichen-Sphagnum dominated bogs furthest inland. The soil gradient in the lowland sites trends from saline Rego Gleysols nearest the coast to Mesisols and Organic Cryosols further inland. Soils grade from Regosols to Podzols to Organic Cryosols on the beach ridges.

Peat Accumulation

Although no detailed stratigraphic or dating research has been carried out, data from selected transects and the emergence rate of 1-1.2 m/100 years suggests an average accumulation of between 50-65 cm/1000 years for southern James Bay. Along the Hudson Bay coast, where a more severe climate and the presence of permafrost becomes a major factor, the accumulation rate is much slower, and is estimated to be between 20-25 cm/1000 years. Differences in accumulation rates between these two areas are reflected in graphs of peat depth vs distance from the coast (Figure 4).

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[3] Soil terminology according to the Canadian system of soil classification (Canada Soil Survey Committee 1978).

Figure 2. Idealized, composite cross section through coastal zone, southern James Bay (modified from Wickware *et al.* 1980).

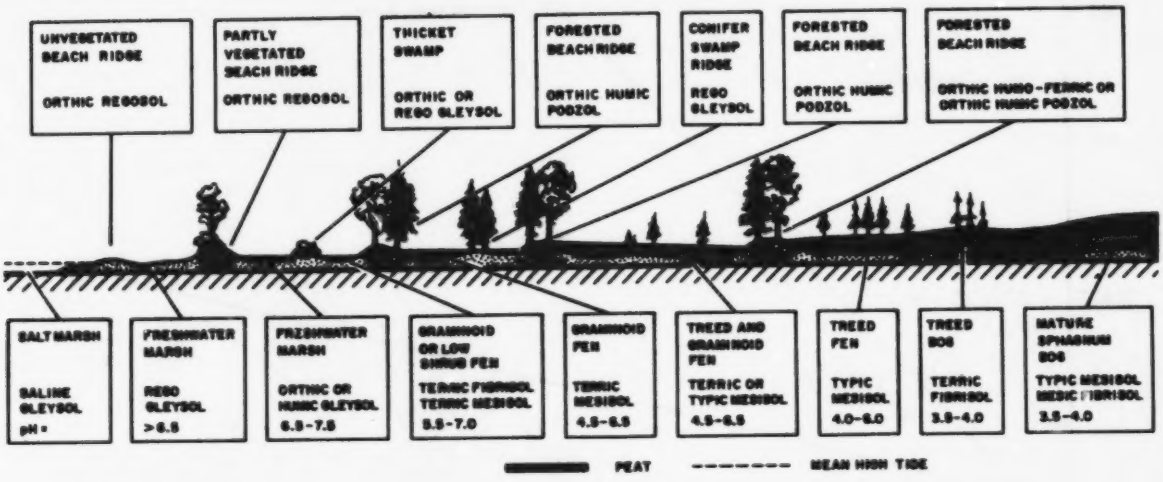


Figure 3. Idealized, composite cross section through coastal zone, Hudson Bay, Winisk Area (modified from Wickware *et al.* 1980).

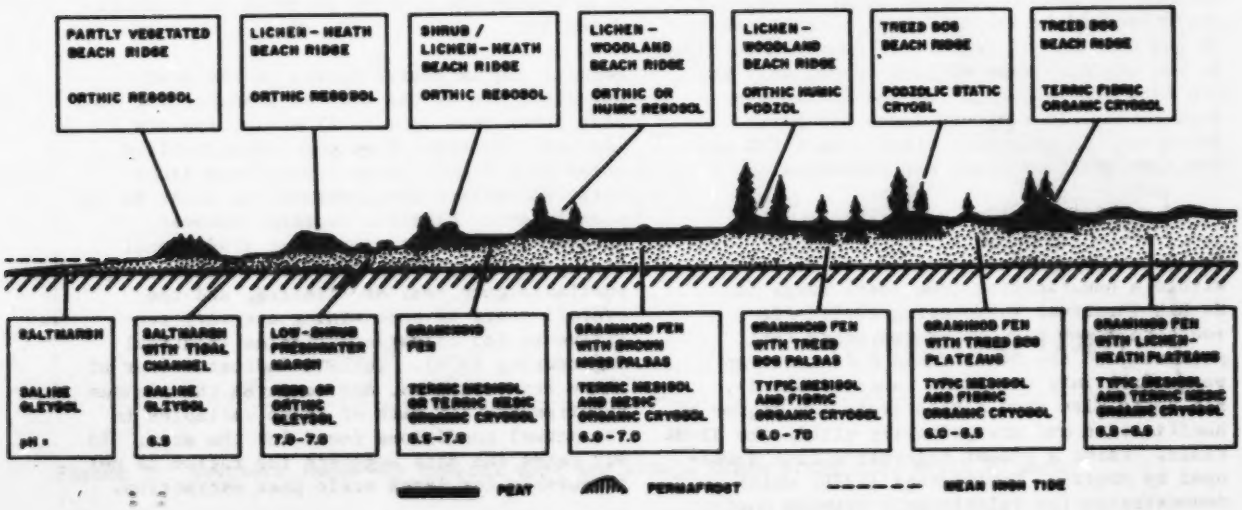
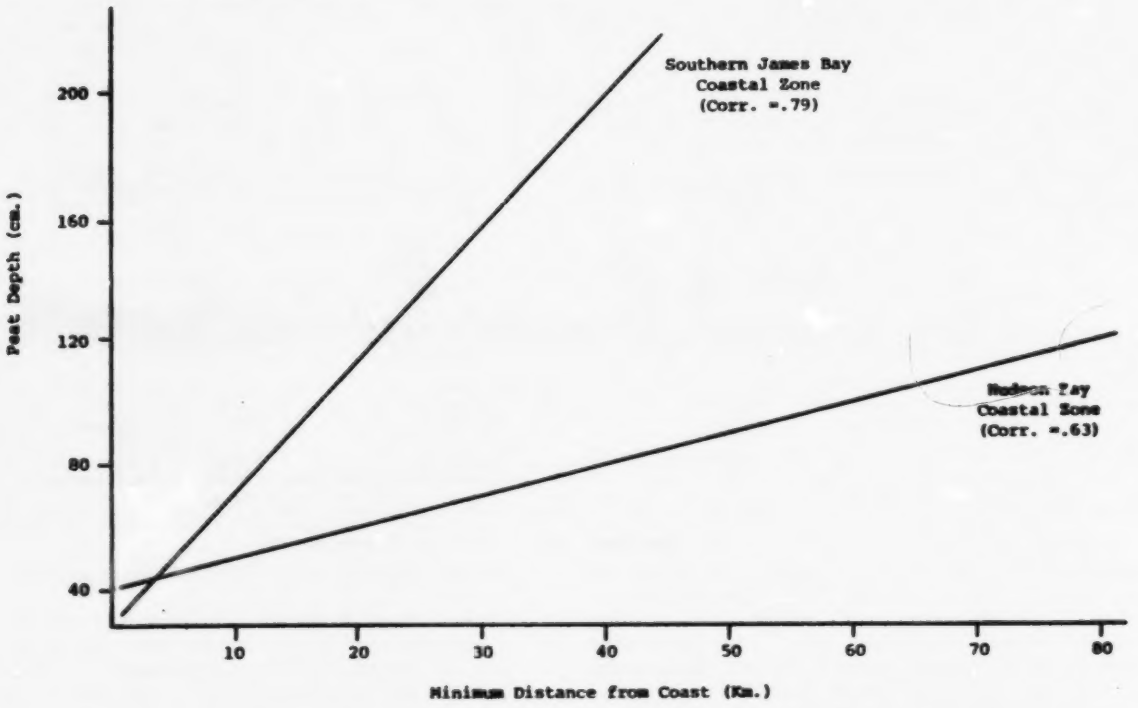


Figure 4. Distance from coast vs peat depth for fens from two H.B.L. coastal zone regions (modified from Wickware *et al.* 1980).



Figures 5 and 6 are generalized contour maps showing peat depth in each of the two study areas.

Peat Characteristics

Characteristics of the peats have been summarized for each of the two study areas, and are presented in Tables 2 and 3. As a result of the presence of permafrost near the surface in the bog and swamp wetland types, only the fen data are presented for the Hudson Bay study area. In southern James Bay where permafrost is generally absent, data for all dominant peatland types are presented.

Potential as a Fuel Peat

Fuel peat is generally considered to fall within a humification (von Post) range of H4-H10 (Montreal Engineering 1978). In southern James Bay, treed fen peats fall primarily in the H4-H5 range and other fen peats fall into the H2-H4 range (Table 2). Bog peats also show a relatively low degree of humification and are primarily within the H2-H4 range. Using a linear regression line developed by Montreal Engineering (1978) which demonstrates the relationship between humification and heat value, peats in southern James Bay have calorific values ranging from 4800 K cal/Kg to 5000 K cal/Kg.

Along Hudson Bay, the fen peats fall within a humification range of H2-H6 with the majority of peat in the H4-H5 range (Table 3). Calorific values are similar to those of southern James Bay.

Despite the extensive nature of the peat deposits, use of the area as a source for fuel peat other than on a local scale, appears limited. Distance from the industrialized areas is a factor which discourages large scale extraction developments, at least in the near future. Climatic factors, however, present a major deterent. For traditional mining methods, the number of productive days available each year are limited, and the overall costs of peat mining are very sensitive to key climatic variables (Montreal Engineering 1978). Table 4 indicates four of these key variables, and compares the minimum requirements for each of these variables to the actual conditions found for the area. In all cases the data suggests the region is not favourable for large scale peat extraction.

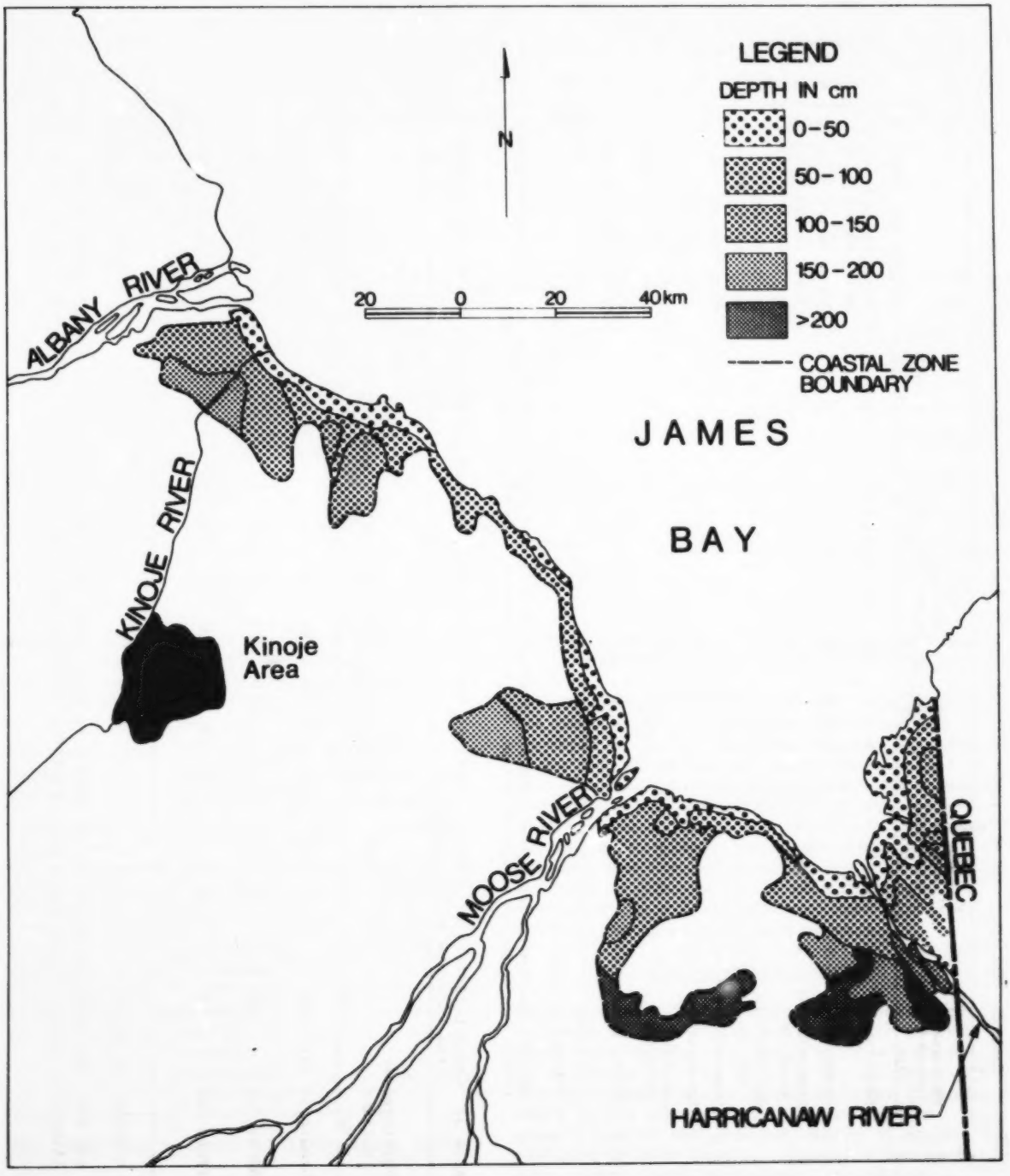


Figure 5: Southern James Bay coastal zone and Kinoje Lakes study area depth of peat.

Table 2. Characteristics of dominant peatland types in Coastal Zone of the Southern Hudson Bay Lowland.

Physiognomic wetland type	n	Mean depth to water table (cm)	Mean % of humification levels in the peat profile[1] 1	2	3	4	5	6	Mean peat depth (m)	Dominant soil type
Shrub fen	16	10	1	27	32	36	5	-	0.8	Terric Fibrisol Terric Mesisol
Graminoid fen	11	5	-	12	15	62	11	-	1.1	Terric Mesisol
Graminoid-rich treed fen	7	15	2	11	15	32	40	-	1.3	Terric Mesisol/ Terric Fibric Mesisol
Sphagnum-rich treed fen	12	17	5	21	3	51	21	-	1.2	Terric Mesisol/ Terric Fibric Mesisol
Graminoid bog	1	13	-	25	-	72	-	-	1.6	Mesic Fibrisol
Low shrub bog	1	13	-	37	20	32	11	-	1.9	Terric Mesisol
Low shrub treed bog	13	28	7	23	18	27	22	2	1.2	Terric Mesisol/ Terric Fibric Mesisol
Conifer swamp	13	17	10	16	17	40	8	9	0.8	Terric Mesisol/ Terric Fibric Mesisol

n = number of plots.

[1] von Post humification values range from 1 to 10 (Canada Soil Survey Committee, Subcommittee on Soil Classification 1978). Percentages are a weighted average, obtained by horizon depth x humification weightings.

Table 3: Characteristics of dominant peatland types in Coastal Zone of the Northern Hudson Bay Lowland. (from Wickware *et al.* 1980).

Physiognomic wetland type	n	Mean depth to water table (cm)	Mean % of humification levels in the peat profile[1] 1	2	3	4	5	6	Mean peat depth (m)	Dominant soil type
Graminoid fen	26	2	16	6	15	59	4	-	0.6	Terric Mesic Organic Cryosol/Terric Mesisol
Shrub fen	3	7	-	23	-	3	45	29	0.5	Terric Mesic Organic Cryosol/Terric Mesisol
Treed fen	6	8	7	19	7	59	8	-	0.7	Terric Mesisol/Terric Fibric Organic Cryosol

n = number of plots.

[1] von Post humification values range from 1 to 10 (Canada Soil Survey Committee, Subcommittee on Soil Classification 1978). Percentages are a weighted average, obtained by horizon depth x humification weightings.

Figure 6. Hudson Bay Coastal Zone, depth of peat. (from Wickware *et al.* 1980).

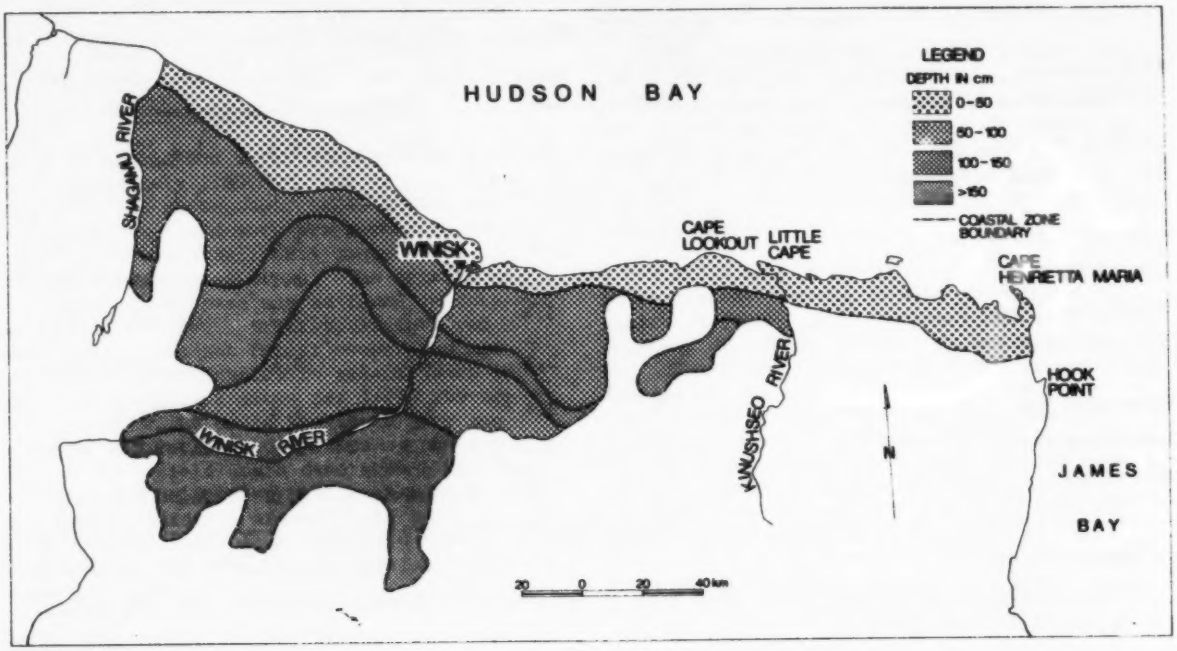


Table 4: Comparison of key climatic variables for the Hudson Bay Lowland, Coastal Zone and the minimum requirements for use of an area for peat production.

Climatic variable	Minimum requirement*	Approx. for area**
Frost free period	16 weeks	< 12 weeks
Bright sunshine	1000 hours	900 hours
Days of rain	60 (maximum number)	60-70
Prevailing winds	Highest % possible. Increases evapotranspiration rate	5%

*As prescribed by Montreal Engineering (1968).

**Chapman and Thomas (1968).

KINOJE LAKES STUDY -- ENVIRONMENT CANADA AND ONTARIO CENTRE FOR REMOTE SENSING

This study was conducted in 1976 in an area in the interior of the southern HBL, located about 85 km WNW of Moosonee, Ontario (Figures 1 and 5). At Kinoje the relative abundance of main wetland types is, from highest to lowest; bog, fen, swamp and marsh. Small areas of mineral soil uplands associated with the banks of the larger lakes, levees of rivers and streams, and old beach ridges are also found. The area is just above the 60 m ASL contour, and occurs in a 'till plateau' area with relatively irregular drainage patterns.

Peat Characteristics

Important peat characteristics are presented in Table 5 (from Jeglum and Covell in press). Peats were sampled for the 0 to 20 and 20 to 40 cm levels in this study. In all types the von Post humification values increase from the upper to the lower layer. In the conifer swamp there is the greatest degree of decomposition in both layers. Generally fen peats are slightly more decomposed, from 0.5 to

Table 5. Characteristics of dominant peatland types in an interior area (Kinoje Lakes) of the southern HBL (Jeglum and Cowell, in press).

Physiognomic wetland type	n	Mean depth to water table (cm)	Peat (0-20 cm) Mean von Post H value[1]	Peat (0-20 cm) Mean pH[2]	Peat (20-40 cm) Mean von Post H value	Peat (20-40 cm) Mean pH[2]	Mean peat depth (m) (range)
Conifer swamp	4	28	4.4	5.2	6.6	5.4	1.2 (0.7-1.8)
Fen pool moss mat	4	5	1.8	4.8	3.1	5.0	2.1 (1.2-2.6)
Graminoid fen	9	-1	2.6	5.2	4.8	5.3	1.7 (0.7-3.5)
Low shrub fen	6	14	2.9	4.9	4.2	5.2	1.1 (0.7-2.2)
Treed fen	9	18	3.1	5.4	4.9	5.5	1.2 (0.9-1.7)
Bog pool moss mat	5	0	2.7	3.4	4.4	3.4	2.2 (2.1-2.5)
Graminoid bog	4	13	2.0	3.4	3.6	3.5	2.2 (2.0-2.4)
Low shrub bog	8	25	2.3	3.2	4.3	3.3	2.6 (2.2-3.0)
Low shrub treed bog	4	40	2.2	2.8	3.8	3.0	2.2 (1.4-2.8)

n = number of plots.

[1] von Post humification values range from 1 to 10 (Canada Soil Survey Committee, Subcommittee on Soil Classification 1978).

[2] Moist-peat pH, obtained by inserting combination electrode directly into fresh moist peat.

1.0 H value, than the bog peats. Peat depths were, on average, less in fens than in bogs. This reflects the development of the Sphagnum peat cap in the raised bogs.

The mean depths of types at Kinoje were deeper than comparable types in the coastal zone, probably owing to greater time for peat accumulation. Peats at Kinoje were not exceptionally deep, in comparison with certain peat-filled kettle holes in other glaciated areas to the south in eastern North America.

THE MAPPING OF WETLAND ECOSYSTEM PATTERNS -- ONTARIO CENTRE FOR REMOTE SENSING

The Primary Data Source

Imagery from NASA's Landsat satellite is the primary data source used in the method of mapping wetland ecosystem patterns which is described in this section of the paper. A satellite in the Landsat series has been orbiting our planet every 18 days since 1972. On each pass, it scans a strip of the earth's surface which is 185 km wide, and it measures and records the reflectance from each scanning element which covers an area of 0.5 ha (1.1 ac) on the ground. Four wavelength ranges of the reflectance of each pixel are recorded, two bands in the visible portion and two bands in the near-infrared portion of the electromagnetic spectrum. The latter bands are essential to the recognition of wetland ecosystems because they are sensitive to the reflectance of chlorophyll-bearing vegetation. The living vegetation of wetland ecosystems, furthermore, is the feature of wetland ecosystems which most effectively indicates the resultant, at any time, of the transactions between all the features of the system.

For the purpose of mapping wetland ecosystem patterns, the best form of Landsat data is the computer-compatible tape (CCT). In this form, each pixel of a Landsat scene (which covers a N.T.S. map sheet area) is assigned four numbers which indicate the appropriate class, within a 64-class reflectivity gradient, of the average reflectance from the surface of the pixel in each of the four bands which are recorded by the satellite. In the form of colour composite prints of a scale of 1:500,000, the imagery provides a synoptic view of the map area which is useful in the preliminary phases of wetland mapping projects. In the form of colour composite transparencies of a scale of 1:1,000,000, the imagery provides a

very useful navigation aid for helicopter travel to preselected field investigation sites located in extensive wetland regions such as the HBL, where few usable benchmarks for navigation are found on topographic maps.

Accessory Data Sources

Field investigation data, airphotos of a scale of approximately 1:60,000, and supplementary colour aerial photography taken during the course of the field work are accessory, but nonetheless essential, data sources for mapping wetland ecosystems. The details of the field study phase may be found in Pala and Boissonneau (1980). Briefly, it involved study of the Landsat colour composites and 1:60,000 scale airphotos to select about 60 field investigation sites per 1:250,000 map sheet area, which would provide a good sampling of the wetland ecosystems of the map sheet. Then field bases were chosen and the locations of helicopter fuel caches were selected so that all areas of the Lowland would be accessible from the field bases. The locations of the field investigation sites are shown in Figure 7.

During the course of the field work, strips of 70 mm supplementary colour photography were acquired using a Vinten camera which was mounted within the helicopter. These strips were acquired in areas which had particularly intimate associations of wetland ecosystems or intimate associations of wetlands and waterbodies. Also, on approach to and takeoff from many of the individual field investigation sites, hand-held 35 mm cameras were used to obtain colour slides of the wetlands in the vicinity of the site.

Finally, the wetland ecosystems at the preselected sites were studied in the field and the following observations were recorded:

1. The wetland types present, within the hierarchical classification framework of Jeglum *et al.* (1974);

2. The vegetation, in terms of physiognomy and dominance;

3. The environmental parameters of peat thickness, depth to water table, pH of the groundwater, the depth to permafrost and, if possible, the thickness of the permafrost layer within the peat.

The accessory data was essential to the phase of the mapping program which classifies the pixels of the Landsat data according to the wetland ecosystems which their reflectance signifies.

Classification of the Pixels of Landsat CCT's

To continue with the HBL example, first Landsat CCT's are selected which were recorded during periods of excellent atmospheric conditions and cloud-free skies. A season of imagery is selected which will provide maximum reflectance differences between the wetland and non-wetland types to be discriminated on each specific CCT.

A PDP 11/34 computer with Norpak and Dipix image display systems is used to perform the image analysis. ARIES software and additional programs developed by the OCRS are used to produce a geometrically-corrected, visual display of the ecosystem patterns of the Landsat CCT's, using the same technique as that used to produce Landsat colour composites. One important advantage of this display over a colour composite is that the scientist can experiment to find a combination of colours which best identify the components of the display. More importantly, he can change the scale of the display, over a very broad range, to best suit his scale requirements for the various steps of this classification procedure.

By an artful use of the accessory data, a set of wetland and non-wetland themes is created which are deemed to accurately identify the components of the CCT display, to be of maximum usefulness to a broad spectrum of users, and to virtually eliminate unclassified elements.

According to the needs of the situation, up to 12 training sites, distributed throughout all parts of the display, may be selected for each classification theme to determine an average reflectance value by which the computer will classify each pixel of the display belonging to that theme.

Although this classification process has been outlined as an unidirectional sequence, it is, of course, a transactional process in which any step may be modified at any stage of the process to obtain an optimal series of map themes.

Use of the Applicon Colour Plotter to Produce Thematic Maps

Having secured a tape on which each pixel of a Landsat CCT is classified as a specific map theme, this tape is then used with an Applicon Colour Plotter to produce a colour map of these themes. Alternatively, the Applicon can

Figure 7: Field investigation sites for wetland classification of the Hudson Bay - James Bay Lowland.

★ Base camp
• Fuel cache
• Field investigation site

produce colour separation masters, for a reduction in the cost of publishing a colour map.

The advantages of these maps over conventional thematic maps are as follows:

1. Conventional mapping programs are necessarily designed for a specific scale of map presentation. Consequently a demand for a different scale of map presentation could only be met by initiating a new program designed for this scale of mapping. The Landsat-based computer mapping method is much more flexible since maps of a given study area can be produced at any scale -- or, for practical purposes, at least within the scale range of 1:250,000 to 1:50,000 within which no additional framework of ecosystem classification or additional accessory data would be required. There are also possibilities of extending the mapping outside the study area and of expanding the scale range by collecting additional accessory data and making minor modifications to the classification framework.

2. Rather than provide the conventional network of lines to segregate the map themes, this method produces a map without lines on which the user may ocularly or manually delineate practical chorological units for his specific purposes where the presence of 'inliers' and 'outliers' is apparent and can be readily quantified.

3. The ecological framework presented in these maps in combination with biological knowledge of wildlife habitat requirements can be used to produce maps of such features as potential summer and winter caribou range, or potential Canada goose nesting sites.

4. The ecological data of these maps can be combined with knowledge of the environmental features of the ecosystems to produce maps showing isopleths of such measures as pH, depth below the peat of groundwater, and peat depth.

Application of this Mapping Methodology to Peatland Inventory

In boreal and tolerant hardwood regions where wetlands occur as discrete areas within a matrix of non-wetland ecosystems, this method can contribute to peatland inventory by indicating the location and extent of wetlands. In addition, ecosystem features which would influence the cost of peat extraction such as the density of tree and low shrub cover, and the presence or absence of mass groundwater flow, could be indicated.

These maps could be produced for areas where Level 3 investigations (in the nomenclature of the report by Monenco 1981, p. 22) are to be undertaken. The ecological framework provided by the maps would facilitate the design and execution of the field work and provide a solid basis for the generalization of the field data to entire peatlands. The maps would be provided at various levels of detail depending upon the current availability of accessory data for the areas to be investigated.

These maps could be used for integrated investigations of peatlands. The basic peatland ecosystem types identified on the maps would provide the basis for stratification of sampling for any number of biotic and abiotic conditions. These could include characterization of peat horizons with differing degrees of humification, peat depths, estimates of volume for various categories of peat humification, peat chemistry and calorific contents, the density of tree and shrub cover, associated wildlife and other ecological conditions.

Finally, at this stage in our cultural development, the environmental impacts of peatland exploitation will have to be addressed. The ecological framework provided by these maps will provide a basis for evaluations of these impacts.

The OCRS is currently producing map sheets at 1:250,000 to cover the whole of the HBL. These should be available in the near future. Summaries of the ground data collected during the aerial reconnaissance are also being prepared.

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WETLAND LAND USE MONITORING IN CANADA

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ABSTRACT

The evaluation of trends in land use changes within and around wetlands of prime importance across Canada is one issue of significant value for development of national strategies concerning the potential use of wetland and peatland ecosystems for energy applications. This paper overviews the current and planned wetland related programs of the Lands Directorate at Environment Canada and provides a discussion of areas of potential cooperation in field studies and research efforts.

RÉSUMÉ

La question de l'évaluation des tendances en ce qui touche aux nouvelles utilisations des terres humides du Canada qui sont d'un intérêt capital, ainsi que des terres qui leur sont adjacentes, est d'une grande importance pour l'élaboration de stratégies nationales relatives à la possibilité d'utiliser à des fins énergétiques les écosystèmes des terres humides. Ce document donne un aperçu des programmes actuels et prévus dans ce secteur à la Direction générale des terres et examine les domaines où il serait possible d'établir une collaboration au niveau des études sur le terrain et des activités de recherche.

INTRODUCTION

Wetlands in Canada encompass approximately 18% of the nation's land surface covering over 1.66 million km^2 as bogs, fens, swamps, marshes and shallow water areas. These wetlands form a key component in the landscape often having critical values for wildlife habitat, nutrient cycling, water and flood management, ecological conservation, recreation, and education. Many of these areas are under land use pressures for urban development, agricultural production, and harbour construction. They also are the source of peat deposits for agricultural and energy development. Zoltai (1980) has estimated that as much as 90% of Canada's wetlands contain peat deposits at least 50 cm thick.

The area in Canada likely to have the most intense conflicts between wetland conservation and wetland utilization for urban, agricultural and energy developments is concentrated in the south closer to cities and productive farmlands. This roughly corresponds to the 2.4 million km^2 covered by the Canada Land Inventory (CLI). An estimate of the amount of peatlands usable for energy development in this CLI area would be 388 000 km^2 potentially.

There is a need for monitoring the effects of land use changes external to and within these wetlands of southern Canada. This paper outlines the wetland programs, in particular land use monitoring, being developed by the Lands Directorate of Environment Canada and addresses the interrelationships between the ecological and developmental perspectives on the utilization of our nation's wetlands.

LANDS DIRECTORATE WETLAND PROGRAMS

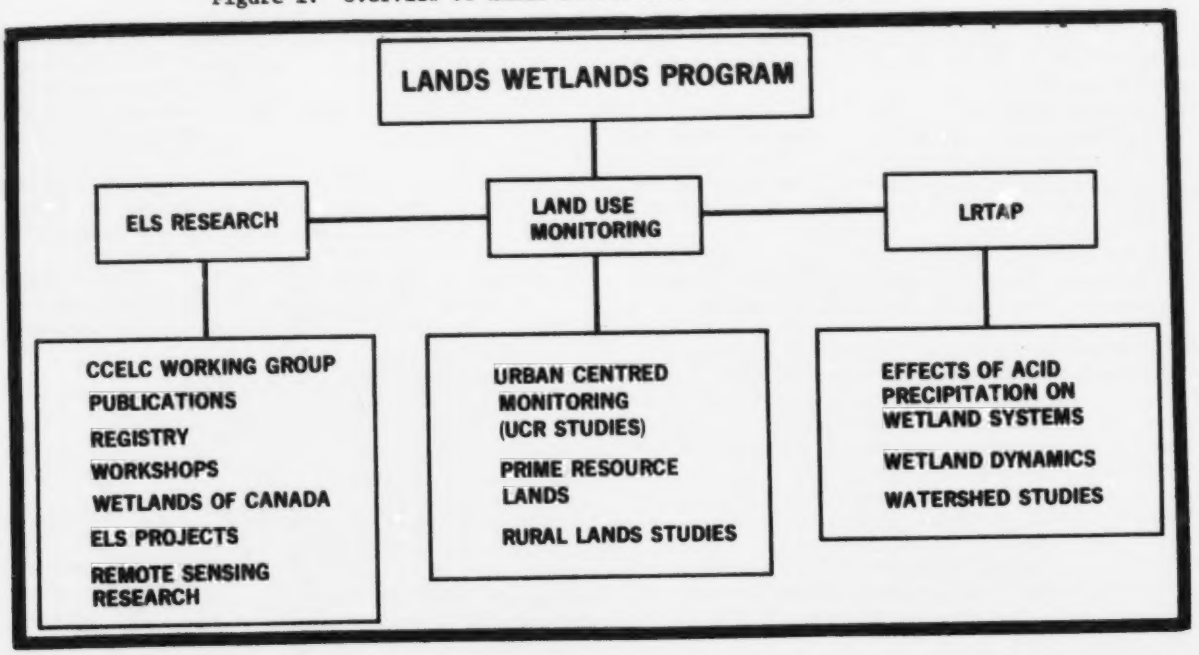
The Lands Directorate has active research interests on Canada's wetlands through three current programs which are outlined in Figure 1. These include:

1) Ecological Land Survey (ELS) Research,
2) Long Range Transport of Airborne Pollution (LRTAP), and the
3) Canada Land Use Monitoring Program (CLUMP).

ELS Research

In terms of wetlands, this program involves development of a national ecological land classification system, research coordination, and information exchange between wetland specialists in federal and provincial agencies and those undertaking field and pilot land surveys. In ecological land surveys, considerable data is usually compiled on wetlands and incorporated in the data bases developed. The main integrating group for these wetland

Figure 1: Overview of Lands Directorate Wetland Programs



activities is the National Wetland Working Group of the Canada Committee on Ecological Land Classification (CCELC).

A secretariat for this committee is provided by the Lands Directorate. It has published outputs of the Wetland Working Group including the *Canadian Wetland Registry* (Tarnocai 1980), *Proceedings of a Workshop on Canadian Wetlands* (edited by Rubec and Pollett 1980), and *Wetlands of Canada* (1981) - a folio of maps on Wetland Regions and Wetlands Distribution. The Directorate has supported four working meetings of the Wetlands Working Group and been directly involved in numerous Ecological Land Surveys including those in the Northern Yukon, British Columbia, Arctic Islands, Beaufort Sea Planning Region, James Bay Development Territory, Hudson Bay Lowland and Labrador. Directorate staff have also undertaken extensive remote sensing research related to wetland applications using Landsat digital data and airborne radar imagery (Howarth and Wickware 1981, Prout 1978, Rubec and Cihlar 1980).

LRTAP Research

Terrestrial ecosystem sensitivity mapping to identify potential acid precipitation impact areas in eastern Canada has been completed (United States - Canada Memorandum of Intent 1981). To improve our understanding of the sensitivity of wetland ecosystems in areas such as the Hudson Bay Lowland, a major research program has been proposed by Lands Directorate in cooperation with the National Water Research Institute to commence in 1982. The purposes of these studies are: (1) to develop a model of the role of wetlands in airborne pollution cycling, and (2) to evaluate the components of wetlands systems most sensitive to acid precipitation. Studies of selected wetlands in calibrated watersheds in Ontario and Quebec also may reveal LRTAP effects on sensitive wetlands. This project is coordinated by Daryl Cowell of Lands Directorate, Burlington, Ontario.

Canada Land Use Monitoring Program

The Canada Land Use Monitoring Program (CLUMP) was initiated in 1978 in response to a cabinet directive to develop a program for monitoring land use change in Canada. The need for the program is based on the fundamental importance of land to the nation, particularly with respect to the economy and land use impacts of federal and provincial policies and programs, the increased scale of developments affecting land, the corresponding expansion in the intensity and intricacy of land use problems, and the lack of an existing comprehensive national land use change monitoring program. Within this framework the objectives established for CLUMP are:

1) To monitor the amount, location, and type of land use in Canada on national and regional scales in support of the production of statistics on land use trends; and

2) to produce national and regional data sets on land use change.

For land use monitoring in Canada, four components of CLUMP have been distinguished on the basis of geographical area, dominant land use, land use change issues, and the rate of change. These components are Urban Centred Regions, Prime Resource Lands, Rural Areas, and Wildlands, with only the first two being operational presently. A fifth component, as outlined in Figure 2, involves Program Development including studies on land use classification, remote sensing monitoring research, sampling strategies, and trend analysis.

Urban Centred Regions: This component of CLUMP, operational since 1979, provides a national perspective on land use changes in the rural urban fringe near Canada's cities. Data for each urban centred region (UCR) is collected on a five year basis, coincident with census years commencing in 1981. A new land use classification for monitoring purposes (Gierman 1981) has been adopted and implemented in 1981. For the period 1966-76, data on UCR's is being compiled from existing sources based on the Canada Land Inventory (CLI) land use classification system. Only cities with population exceeding 100,000 have been examined thus far in these studies. A national overview report will be prepared in 1983.

Prime Resource Lands: This component of CLUMP was initiated in 1981. Prime resource lands can be labelled "special", "unique", or "critical" ard may be in use for agriculture, forestry, wildlife, recreation, mineral development, or energy activities. They are usually defined on the basis of their inherent physical or environmental qualities or socio-economic factors which interact on the land to allow production of goods and services essential to the economic, environmental or social well-being of Canada.

Prime resource lands often are subject to resource use conflicts from land use changes such as urban development of agricultural land conversions. Conversion of prime wetlands is affected by both of these factors. Reliable information on the dynamics of land use changes on prime resource lands is important to all levels of government, the private sector, and the public in order to evaluate land use patterns and to develop programs and related policy.

The initial focus of the Prime Resource Lands component, as outlined in Figure 3, is prime fruit growing lands across Canada. It will consist of regional data sets and reports for the Okanagan Valley, Niagara Peninsula, Southern Quebec, Annapolis Valley and also a national overview data set and report. A combined land

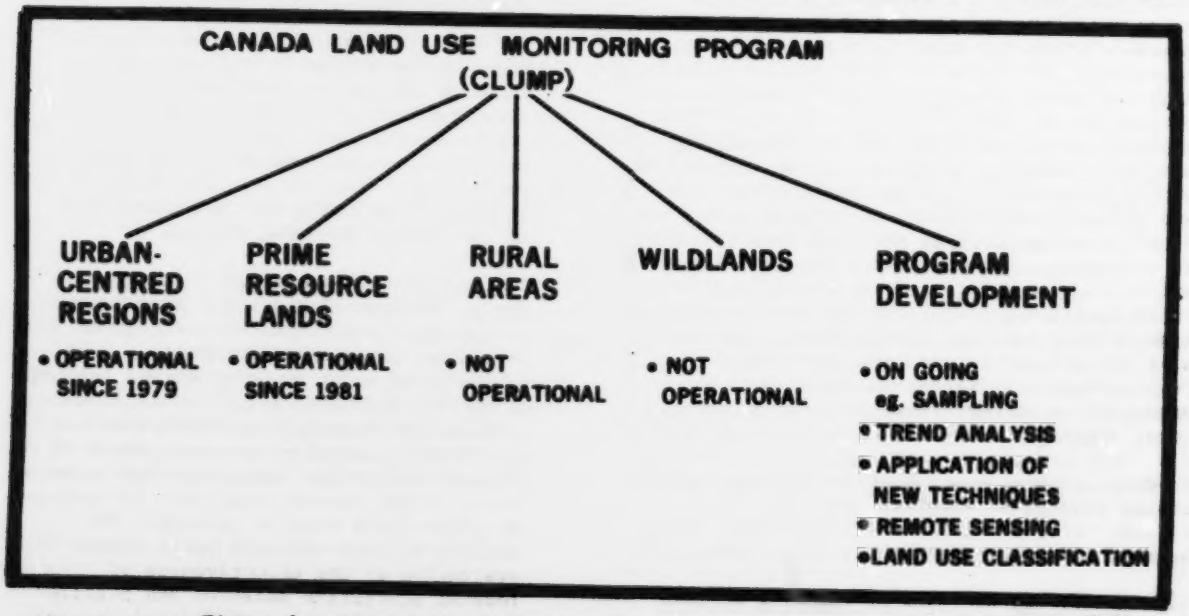
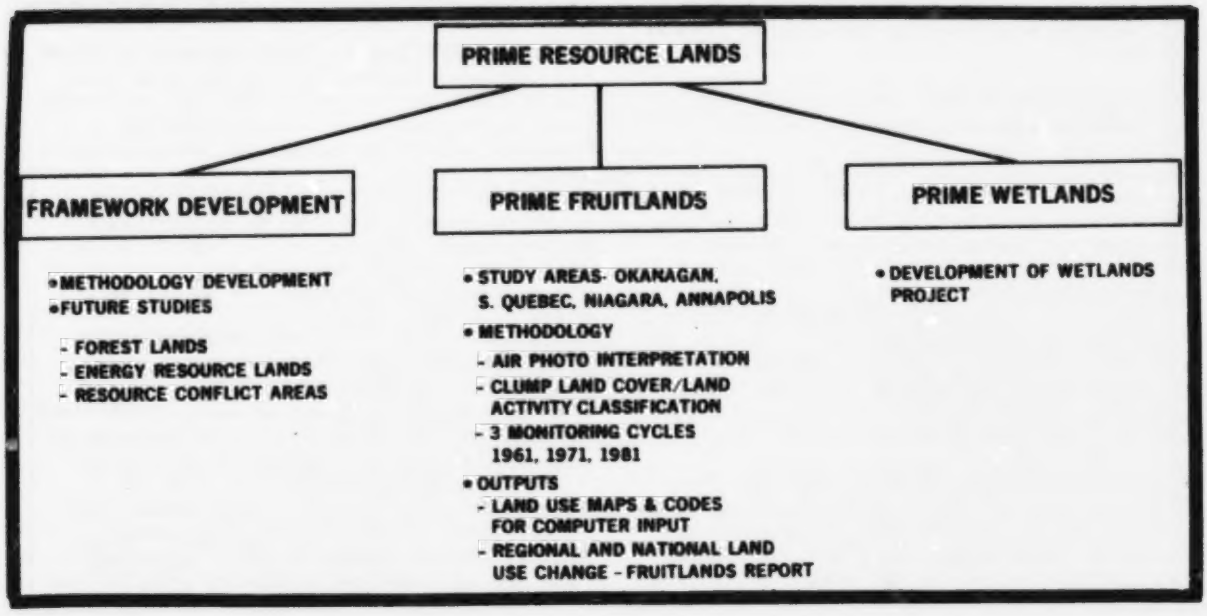


Figure 2: Components of the Canada Land Use Monitoring Program

Figure 3. Current elements of the CLUMP Prime Resource Lands Component.


PRIME RESOURCE LANDS
FRAMEWORK DEVELOPMENT
PRIME FRUITLANDS
PRIME WETLANDS
•METHODOLOGY DEVELOPMENT
•FUTURE STUDIES
- FOREST LANDS
- ENERGY RESOURCE LANDS
- RESOURCE CONFLICT AREAS
• STUDY AREAS- OKANAGAN, S. QUEBEC, NIAGARA, ANNAPOLIS
• METHODOLOGY
- AIR PHOTO INTERPRETATION
- CLUMP LAND COVER/LAND ACTIVITY CLASSIFICATION
- 3 MONITORING CYCLES 1961, 1971, 1981
• OUTPUTS
- LAND USE MAPS & CODES FOR COMPUTER INPUT
- REGIONAL AND NATIONAL LAND USE CHANGE - FRUITLANDS REPORT
• DEVELOPMENT OF WETLANDS PROJECT

cover/land activity classification (Gierman 1981) is being used for the time periods 1961, 1971 and 1981.

Prime Wetlands: With studies on prime fruitlands now underway, a second project of the Prime Resource Lands component - a study of Canada's prime wetlands, is presently being developed. The focus of these studies will be land use change adjacent to and within prime wetland areas. The combined land cover/ land activity developed for CLUMP (Gierman 1981) may be utilized. Research will be framed within the context of a national perspective and will primarily relate to federal jurisdictions or mandates in areas of federal lands or interests. Prime wetlands studies will use and build upon existing data bases and studies which classify and evaluate wetlands or provide quantifiable land use change data. Studies will be confined to southern portions of Canada where significant land use change pressures exist upon those wetlands of national significance.

To date, several possibilities for land use change studies on wetlands have been identified. Of these (a) and (e) have been implemented. The others are still being considered.

(a) A national overview of existing wetland data sets and change statistics: A contract has been let by the Directorate to identify and consolidate information on existing wetland data bases, wetland values, current research, and approaches to study of wetland change.

(b) Wetland changes near urban centred regions: With some manipulation of UCR data sets for 1966, 1971 and 1976, an evaluation of the trend in change of wetlands near Canadian cities to urbanization and other uses would be undertaken. The approach would use existing data in these areas of extreme land use pressure on wetlands of particularly high value. The study is restricted to the relatively small area of the nation near the cities.

(c) Wetland changes on federally managed lands: To date 82 Migratory Bird Sanctuaries and 39 National Wildlife Areas have been established in Canada. Most are centred on or contain wetland habitat areas for migratory birds. Only those sites which exemplify wetland values or are under development pressure would be studied initially. Threatened wetlands within other federal land such as national parks could also be studied. The results of this research would assist in evaluation of the effectiveness of federal protective measures and policies for wetlands in areas of federal interest.

(d) Land use change in Canada's wetland regions: Within the wetland regions of southern Canada identified in the National Wetland Working Group map folio *Wetlands of Canada* (1981) selected representative prime wetlands could be studied to overview trends in land use change. Examples of regions for study might include the Pacific Oceanic Wetlands Region (OP); the Continental Prairie Wetlands Region (PC) which includes the prairie pothole areas; Eastern Temperate Wetlands Region (TE) which includes the St. Lawrence Lowland and the Great Lakes shoreline; and the Atlantic Boreal Wetlands Region (BA) which includes coastal salt marshes.

(e) Wetland loss in southern Ontario: The Lands Directorate Ontario Region has underway a project, coordinated by Elizabeth Snell, to map the wetlands of southern Ontario on one hundred twenty-five 1:50,000 scale maps. The study uses overlays of CLI land use and soil capability maps. All soil capability classes with a wetness limitation (subclass "w") and organic soils (class "O") are overlain with land use maps. Whenever natural vegetation classes for marsh (class "M") and forest (classes "T" and "U") coincide with wet soils, a wetland likely existed in 1966. If a wet soil does not overlay with the above land use classes, it is assumed the wetland has been converted to other uses. These studies indicate that 70% of the original, pre-settlement, wetlands in southern Ontario had been converted by 1966 to other uses. About 54 100 km^2 of wetlands exist now in this area (Snell 1981). The feasibility of adapting this approach for application to other areas covered by the CLI is now being investigated.

A COOPERATIVE, COORDINATED APPROACH TO WETLAND STUDY IN CANADA

It is recognized that many other agencies exist in Canada with active interest in wetland studies. The focus of the current meeting has been the potential for development of peatland for energy uses. The Peat Forum will undertake studies in cooperation with specific federal and provincial agencies to evaluate the location, amount and quality of peat in Canada's wetland areas. We believe considerable opportunities exist for cooperative efforts in peatland research and inventory which directly involve many of the aspects of the land use monitoring studies outlined in this paper. These may include:

(a) Site selection: The choice of peatlands for detailed study ideally should consider whether such a site is representative of the Wetland Region where it may be located; the significant wetland values of the location; the effects of external and internal land use pressures on the site; as well as its essential values as an energy peat source area.

(b) Data collection and use of resources: The efficiencies of cooperative use of aircraft, manpower and fiscal resources between interested agencies could permit a more detailed and more widely applicable data base on peatlands beyond immediate peat for energy concerns.

(c) Laboratory and computer facilities: The analysis of field samples and data input and retrieval via computer information systems are but two examples where significant cooperation on wetland/peatland studies would have impacts of national importance.

In all these areas, the Lands Directorate is keenly interested in and capable of providing unique and highly capable expertise as well as computer data base facilities for cooperative studies on wetlands through its four regional and its headquarters offices.

SUMMARY

The development of national peatland inventory and evaluation strategies can benefit greatly through cooperation with agencies with expertise and ongoing research programs on Canada's wetland ecosystems. The Lands Directorate of Environment canada is one such agency with innovative studies on wetlands relating to ecological land survey, long range transport of airborne pollution, and land use monitoring. In particular, the study of land use conflicts in areas of high potential for peatland development could be an extremely important component of Peat Forum proposals. These proposals would benefit directly by reference to the Lands Directorate land use monitoring program.

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UPDATE ON THE QUEBEC PEATLAND INVENTORIES

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ABSTRACT

Over the past 10 years, numerous wetland inventories have been carried out in southern Quebec notably for horticultural and peat fuel stock evaluations. The Energy and Resources Department (MER) have compiled, for the last 15 years, peatland information in southern Quebec; inventories being based on photo interpretation controlled by field checks. Through a SOQUEM research program (production of coke from peat) 98 peatlands have been photointerpreted and sampled and information compiled for 285 peatlands in the southern, northshore and Abitibi regions of Quebec. In planning industrial use of peat as fuel, Hydro Quebec, through its "Power Plant Projects" division, has initiated a peat fuel study program for areas south of 51st parallel. This plan was developed in three stages, the last of which applies to potential site location for thermal power generating stations by systematic sampling; including profile cores on all major peatlands concerned. Besides this study, a peatland survey was carried out on Anticosti Island in order to supply Port Meunier with electricity produced from peat gas.

Other wetland inventories, not specifically concerned with peat stock evaluations, are the James Bay peatland ecological study 1979 by Environment Canada, the Laurentian park peatland vegetation study (1980) by Robert Gauthier, and the South Jamesie peatland study by Grondin and Ouzilleau (1980), a three tier classification adapted for photointerpretation. The group "Dryade" has also completed a C.W.S. contract to inventory and map habitats used by migrating avifauna along the major rivers of southern Quebec.

RÉSUMÉ

Des inventaires sur les terres humides ont été menés activement ces dernières années dans les régions méridionales du Québec, notamment en vue d'évaluer les volumes de tourbe, soit pour l'horticulture, soit comme combustible potentiel. Le ministère de l'Energie et des Ressources (MER) recueille depuis une quinzaine d'années des informations sur les tourbières du sud du Québec; sa méthode de travail dépend de la photointerprétation des physionomies végétales appuyée de contrôles sur le terrain. La SOQUEM a poursuivi, dans le cadre d'un programme de recherche sur la fabrication de coke de tourbe, un programme d'échantillonnage de 98 tourbières, d'inventaires photogrammétriques ainsi qu'une synthèse des données disponibles pour le sud du Québec, la Côte Nord et l'Abitibi. L'Hydro Québec, en vue de planifier l'usage industriel de la tourbe combustible a entrepris un plan d'étude des tourbières au sud du 51^{e} parallèle; ce plan procède selon trois niveaux d'estimation de la ressource, dont le dernier le plus précis, est appliqué dans les secteurs d'implantation potentiels de centrales thermiques au moyen d'un échantillonnage systématique sur toutes les tourbières concernées. On a parallèlement mené un inventaire des tourbières de l'île Anticosti et un plan d'implantation d'une génératrice à base de gaz de tourbe à Port Meunier.

Parmi les inventaires de milieux humides non liés spécifiquement à la connaissance du volume de la ressource tourbe il y a l'étude des tourbières de la Baie James (1979) réalisée par Environnement Canada, l'étude des tourbières du parc des Laurentides (1980) par Robert Gauthier et l'étude des tourbières du sud de la Jamésie, par Grondin et Ouzilleau (1980), une classification des tourbières à trois niveaux de perception adaptée à la photointerprétation. Le groupe "Dyrade" a aussi réalisé, pour le compte du Service canadien de la faune, un inventaire des habitats propices aux oiseaux migrateurs le long des principaux cours d'eau du Québec.

INTRODUCTION

Over the past ten years, numerous public and parapublic organizations have become involved more and more in wetland research projects. The study objectives, sampling techniques and results are defined by each organization involved in peatland surveys. For example, the James Bay Development Corporation has studied the floating bog phenomenon commonly occurring on northern reservoirs, while Hydro Quebec has been interested in the feasibility of using peat as alternative fuel source for producing electricity in isolated regions.

This paper presents past and current peatland research programs as well as a discussion on what lies ahead for Quebec in this field. Due to the different types of research being done, an attempt will be made to qualify the projects using the following categories:

- Resource inventory: Inventories to evaluate the amount of peat available to the horticulture industry or as alternative fuel. Studies have been carried out in southern Quebec to evaluate peatland potential for market garden crop production. A systematic approach to peatland inventories has been developed.

- Ecological land inventories and studies: Perhaps misnomer, but this term covers all inventories other than those designed to evaluate peat volume. Criteria such as landform, vegetation and soils are used in the ecological classification approach. This type of inventory includes wetlands with little or no peat development such as coastal marshes, swamps, etc. Phytosociological studies, such as these, have been made possible through research funding or impact studies but have had limited application.

RESOURCE INVENTORY

The provincial government (MER) to date has been involved in the agricultural use of peatlands. However, recently, it has oriented its interests toward the use of peat as an alternative fuel. For the last 15 years, provincial specialists have compiled, in the St. Lawrence River Valley, data for the peatland potential of areas greater than 100 hectares. The available data proved to be insufficient for energy planning purposes as well as for other uses. However, since 1977, the inventory included an evaluation of the humic layer. Inventories are based on photo interpretation controlled by field checks. "La Direction des énergies nouvelles" (MER) participates with Hydro Quebec in the research and development of new products from this resource.

The SOQUEM, through a research program, designed to produce coke from peat, has inventoried by photo interpretation and sampled 98 peatlands and compiled information on 285 peatlands from the southern, northshore and Abitibi regions of Quebec.

It must be noted that although agriculture can use peatlands for market gardening, the peat prevents the underlying soils from being cultivated. In the lower St. Lawrence River region intensive culture on peat is presently being monitored. Laval University contributed to this research by analyzing the horticultural properties of the collected samples, while Sherbrooke University performed analysis on the samples for fuel.

In order to plan for industrial use of peat as fuel, Hydro Quebec, through its "Power Plant Projects" division, has initiated a peat fuel study program on areas south of the 51st parallel, which are the most economically and climatically exploitable zones at the moment. This program was developed in three stages:

1st stage: a global synthesis for southern Quebec;

2nd stage: medium-level surveys in high peatland density zones;

3rd stage: detailed local studies of potential sites.

The first stage is practically finished and indicates all the available peatlands for industrial uses. For this purpose, all the cartographic units included in the "humid barren" class (forest cover under 25 percent and identified as a humid site) and extending over at least 100 ha were compiled on the forestry maps published by the Energy and Resources Department (formerly Lands and Forests Department). Accompanying this map, is a data bank presented as descriptive file for each map unit. These files contain the main parameters readily obtainable from forestry and topographic maps such as location, watershed, altitude, unit (whether compact or dissected), relative position to water bodies, etc. Some peatlands were morphologically interpreted on aerial photographs along with water regime and plant physiognomy. Nearly 800 000 ha were thus compiled within the defined study limits. According to Hydro Quebec officials, a certain error factor has to be accounted for, as the wooded peatlands and wetlands located in agricultural zones might have been overlooked.

Knowing the zones with a high peat density, as defined in the first stage, the second stage investigations will focus on detailed analysis of on site climatic conditions, plant physiognomy mapping as discernible by photo interpretation, low-density sampling for volume approximations, and regional socio-economic studies.

The third stage is locally applied to potential site implantation for thermal power generating stations. The "Lac St. Jean" peatland study (by Dryade Inc.) is a typical example of stages two and three combined. A systematic sampling program including profile cores, has been performed on all the major peatlands in the region (over 20 000 ha). This work included the mapping of the horticultural peat (Von Post's H1, through H3) and fuel peat (Von Post's H4 through H10) thicknesses. It also provided the profiles of each of the sampled peatlands, as well as a detailed description including thickness, degree of humification, peat type, surface vegetation, etc., and finally it defined precisely the existing and exploitable stocks on those peatlands. It is hoped that this peat will provide the raw material for a 300 megawatt thermal power plant.

Besides this study, some areas were considered to complete feasibility studies including identification of reserves, detailed surveying and the analysis of different exploitation methods. The main effort in this respect was concentrated on Anticosti Island where it appeared economically and socially profitable in the long run to replace the existing oil burning power plant that provides Port Meunier with electricity by a system that would use peat as a fuel.

Before getting into the ecological study discussion, let us mention that the research people responsible for those various surveys have noticed a close relationship between evolutive forms observed in the peatlands and the habitat characteristics. This relationship has been observed empirically though and unfortunately no actual analysis has been performed to confirm it.

ECOLOGICAL SURVEYS AND STUDIES

Many studies were carried out on Quebec peatlands and wetlands especially in the southern part. An exhaustive list of peatland vegetation studies was presented by Robert Gauthier (1980). Let us mention that the principal peatland classification systems proposed and used so far in Quebec are those of Zoltai *et al.* (1973), amended by Zoltai (1976), Jurdant and Bélair (1974), Jeglum *et al.* (1974) and Grondin and Ouzilleau (1980).

Our intention is to present a brief presentation of three of those studies in order to illustrate the main aspects of the classification as applied in Quebec:

- James Bay area peatland study by Zarnovican and Bélair (1979);
- peatlands of the southern part of the James Bay territory, Quebec, by Grondin and Ouzilleau (1980);
- favourable habitats for migrating birds by the Dryade group (1980).

The James Bay Area Peatland Study

The James Bay Ecological Land Survey (ELS) was carried out from 1973 to 1975. This project followed the completion of an ELS pilot project in the Saguenay-Lake St. John area, especially set up to develop a method of surveying vast, remote and inaccessible areas in a relatively short period of time at a minimum cost. The key to the methodology was photo interpretation. All mapping, at 1:125 000, was to be done using conventional black and white aerial photos with minimum field checks.

In the James Bay survey, the importance of the wetlands was immediately recognized. Autochtons have a different concept of wetlands compared with ours, as it includes the highly productive shoreline along lakes, rivers and streams. This was accepted as part of the classification along with the general definition of wetlands.

The objective of the three year project was to provide a general picture of the potential of the natural resources for land management. Other people perceived it as a collection of basic data for impact assessment of hydroelectric developments, which was not the case, as the study dealt mainly with the potential of the resources and not the actual state of the resources. This misconception has fired many a long discussion.

Methodology - As the entire mapping program for the first field season was to be completed before the second field season, the ecotype classification included in each map unit was determined before the field data analysis was completed. It goes without saying that the wetland classification, including the peat landforms, was made in a hurry with very little information other than what has been observed in one summer's field work.

Peat landforms classification - The deep organic terrain (greater than 1 m) was classified using two landforms: bog and fen. Each one was then defined as either treed, structured or non-structured. The shallow organic

material (less than 1 m) was also classified as bog or fen and each classified as either organic material on mineral soil other than clay, over clay or bedrock. Finally, the palsas were classified as such. These ecotypes were relatively easy to photo interpret and to include in the definition of the mapping unit.

Field data analysis - Following three field seasons, an analysis of the vegetation on organic soils was carried out. Four hundred forty-nine sample plots were established on organic soils of which 280 met the *sensu* CSSC criteria for organic soils.

For the entire study area 30 soil series and 13 vegetation groups were established. In general, the dominant organic soil was a mesisol with a surface tier composed mainly of *Sphagnum*. The depth of organic material decreases from the south to the north. The presence of calcium and magnesium decreases from the southwest to the northeast. Botanical origin, a soil series classification criteria proved not to be significant enough to subdivide the families.

The relationship between soil series and vegetation groups was difficult to establish. However, it was possible to identify trends at different classification levels.

The relationship between ecotypes and vegetation groups was much better and could be used, after regrouping, with an acceptable degree of confidence.

Perspective for the future - The James Bay fieldwork, the mapping and the classification have proved to be costly. The data, although relatively small in quantity, is extremely complex making analysis by statistical models using a computer essential. Statistical random sampling in this type of survey requires a strict adherance to predefined procedures covering all phases of the project.

To help simplify the random sampling, Landsat imagery should prove to be an essential tool. It is fairly easy and not too expensive to produce a map of actual vegetation cover using Landsat imagery for large remote areas. This data source was suggested for use in the pilot projects around 1976. In many cases this type of map has fulfilled most of the developers' needs. Examples of these maps are available for some areas in northern Quebec and the Quebec North Shore.

Random sampling would be recommended when more detailed information is required to determine ecological relationships between soil, vegetation or any other criteria.

The basic document - It was and may be still believed that a survey made by soil and vegetation experts can accurately represent an area making subsequent surveys unnecessary. However, this representation is not that simple and will differ according to the objectives pursued by each project. Organic terrain is neither simple nor more complex, it is only different from mineral soil, and a lot more research will be needed to identify organic terrain genesis in order to develop guidelines for management, protection and subsequent exploitation of these landforms.

The Peatlands of Southern Jamesie, Quebec

The consultant firm "Dryade Inc." was given a mandate by the S.E.B.J. Environment Directorate to conduct a peatland study in connection with the development of the hydroelectric potential of the Nottaway, Broadback and Rupert rivers.

This study presents a classification of the peatlands located in the southern part of the James Bay territory. This classification tends to be simple, adapted for photo interpretation and appropriate for several purposes. It recognizes three classification criteria: vegetation groups, morphological units and peatland types. Twenty-two vegetation groups were identified and described according to the dominant and subdominant species of several sampling sites. Each group occupied a definite position along the hydrosere and can be recognized by the observer going about the peatland. According to the different arrangements within these groups, the distribution of ponds, the vegetation structure and the proximity to the water's edge, 12 morphological units are identified. All these units are identified by the observer flying over the area at low altitude or by the photo interpreter. At a higher level of recognition, noticeable by the observer located at mid altitude, six peatland types are identified in regard to their nutritive regime and their topographical situation. Finally, an overview of the whole area allows the designation of five peatland regions based upon the relative importance of morphological units and peatland types.

This classification system permits us to interpret information on a regional, local or

specific site basis. Conceived for integration on different perception scales, these three levels are used to draw a regional picture of the peatlands in the southern Jamesie.

FAVOURABLE HABITATS FOR MIGRATING BIRDS

The group Dryade has also completed a study for the Canadian Wildlife Service to inventory and map the habitats used by migrating species along the major rivers of southern Quebec. Identification and location of coastal marshes on air photos have been transferred to base maps (scale of 1:20 000). Vegetation groups have been classified from a bibliographic synthesis of existing sectorial studies.

The results indicate an area of 39 000 ha of coastal marshes (submerged and emerged communities) in fresh water zones and about 3900 ha of herbaceous communities dominated by American Bulrush in fresh water zones under tidal influence. Nine thousand hectares of coastal marshes were identified in the St. Lawrence River Estuary, in the salt water zones, 2400 ha scattered along the North Shore and Gaspesie coasts and 2200 ha in the Iles-de-la-Madeleine.

The specialists found, by analysis of selected zones such as Bassin de la Prairie and Kamouraska, that human activity on coastal marshes has increased in the last 30 years.

The bibliographic review for this project, indicated a lack of information in some zones; notably the salt marshes of Gaspesia, the Estuary and the North Shore coasts.

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PATTERNED PEATLANDS OF LABRADOR: A CLASSIFICATION AND INVENTORY PROBLEM

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ABSTRACT

The peatlands of Labrador are mainly patterned with pools and strings of vegetation orientated at right angles to direction of slope. Since both fens and bogs have these surface features the identification and classification of different peatland types from conventional aerial photography is usually very difficult without ground truthing. This is an expensive component of any classification and/or inventory project; consequently, several peatland sites have been selected to determine if landsatellite imagery can be successfully employed to delineate and classify different bog and fen types.

RÉSUMÉ

Les tourbières de Labrador sont pour la plupart caractérisés par les mares et par les files de végétation orientées à angle droit avec la direction de pente. Comme les tourbières ombrotrophées aussi bien que les tourbières minerotroprées ont ces traits de surface, l'identification et la classification de divers types de tourbière utilisant la photographie aerienne conventionnelle sont ordinairement très difficiles sans vérification à terre. Ceci constitue une partie coûteuse d'aucune classification et/ou projet d'inventaire; par conséquent, des plusieurs types de tourbière ont été choisis pour déterminer si on peut utiliser avec succès l'imagerie de satellite-terre afin de délinéer et classifier de divers type de tourbière ombrotrophée et de tourbière minerotropnée.

Peatlands form a large component of the Labrador landscape; a conservative estimate of their extent is about six million hectares. They are especially predominant along the headwaters of the Eagle, Paradise, Big, Kenamu, Goose, Naskaupi, Alexis and St. Lewis Rivers in eastern and central Labrador, and throughout the headwaters of the Smallwood Reservoir in western Labrador (Figure 1). North of 50° latitude, the terrain is mountainous, scraped clean of overburden and dominated by bedrock, frost-shattered colluvium and erratics; organic deposits are rare and confined mostly to coastal sites or deep glaciated valleys.

Unlike the peatlands that occur throughout much of Atlantic Canada, many of the peatlands in Labrador have similar morphological and physiognomical features. Both bogs and fens are often characterized by an abundance of parallel pools and ridges of vegetation orientated at right angles to the direction of slope (Figure 2). These peatlands are generally referred to as "patterned" peatlands; however, this term is very general and can be applied to any type of peat deposit that has a recognizable pattern on its surface. In the Hudson Bay Lowlands, Sjörs (1961a, 1963) has described expanses of "densely-rippled micropatterned" minerotrophic peatland with large circular partly ring-shaped black spruce islands. Patterned fens, string fens, string bogs, and aapa mires have also been reported throughout much of the Hudson Bay Lowlands (Ritchie 1960, Sjörs 1961a, 1961b) and near Great Slave Lake, NWT (Pakarinen and Talbot 1976). In northern Minnesota many of the peatlands resemble flow features (Glaser *et al.* 1981); these "water-tracks" have alternating strings and pools as well as "islands" that are tear drop-, circular-, or horseshoe-shaped. Similarly, in northern Michigan, Heinselman (1965) described string bogs and "topographically-oriented strips of bog forests". In the Arctic many of the perennially-frozen peatlands have polygonal surface patterns (Zoltai and Tarnocai 1975). Patterned peatlands have also been reported for Alaska (Drury 1956) and the northern regions of the USSR and Finland (Bellamy 1972, Eurola and Kaakinen 1979, Kivinen and Pakarinen 1981). In Newfoundland the ladder fens, ribbed fens and many of the domed bogs (Pollett and Wells 1980, Wells 1981) are also forms of patterned peatlands.

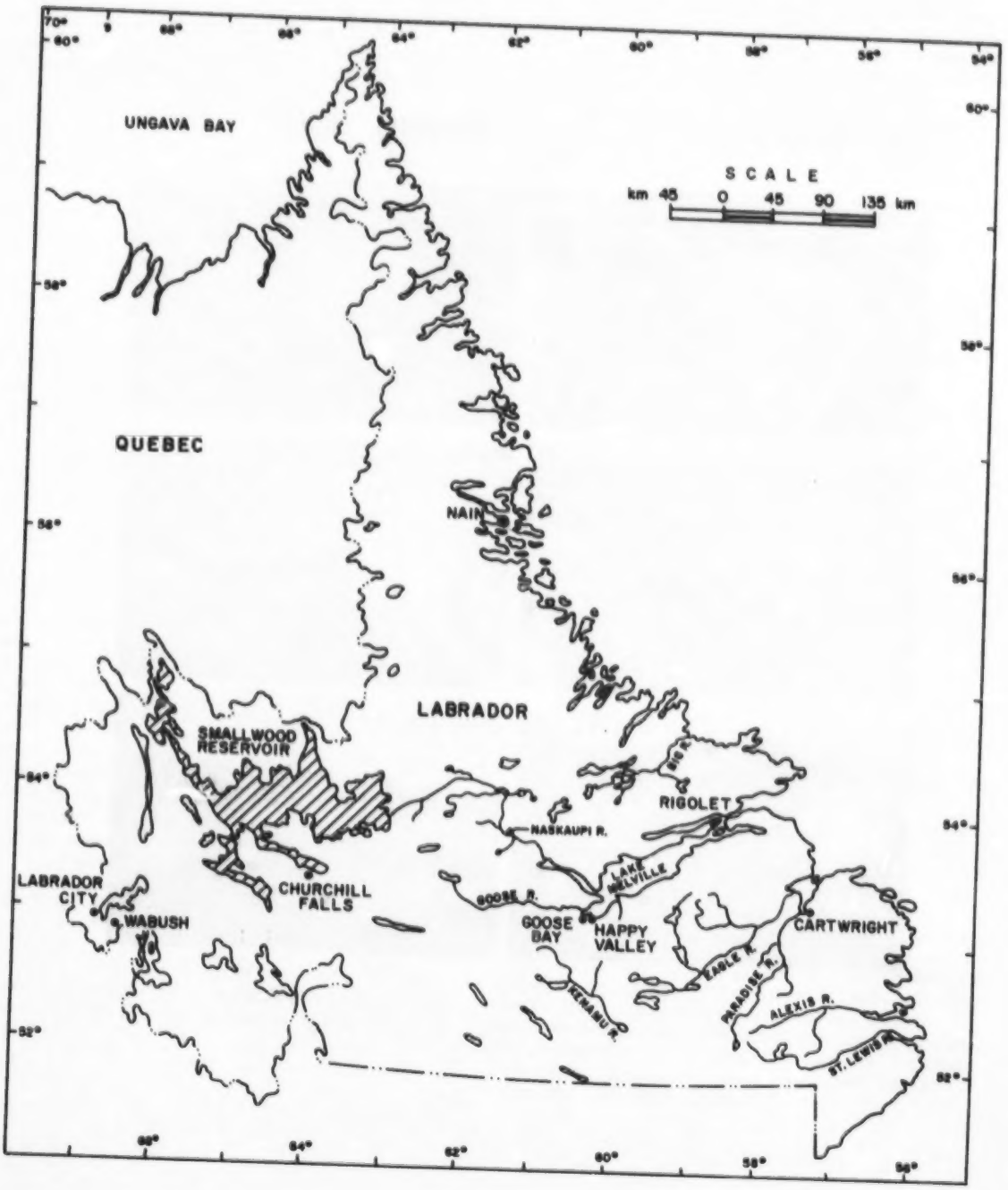

Figure 1: Map of Labrador showing major watersheds and locations of extensive peat deposits.

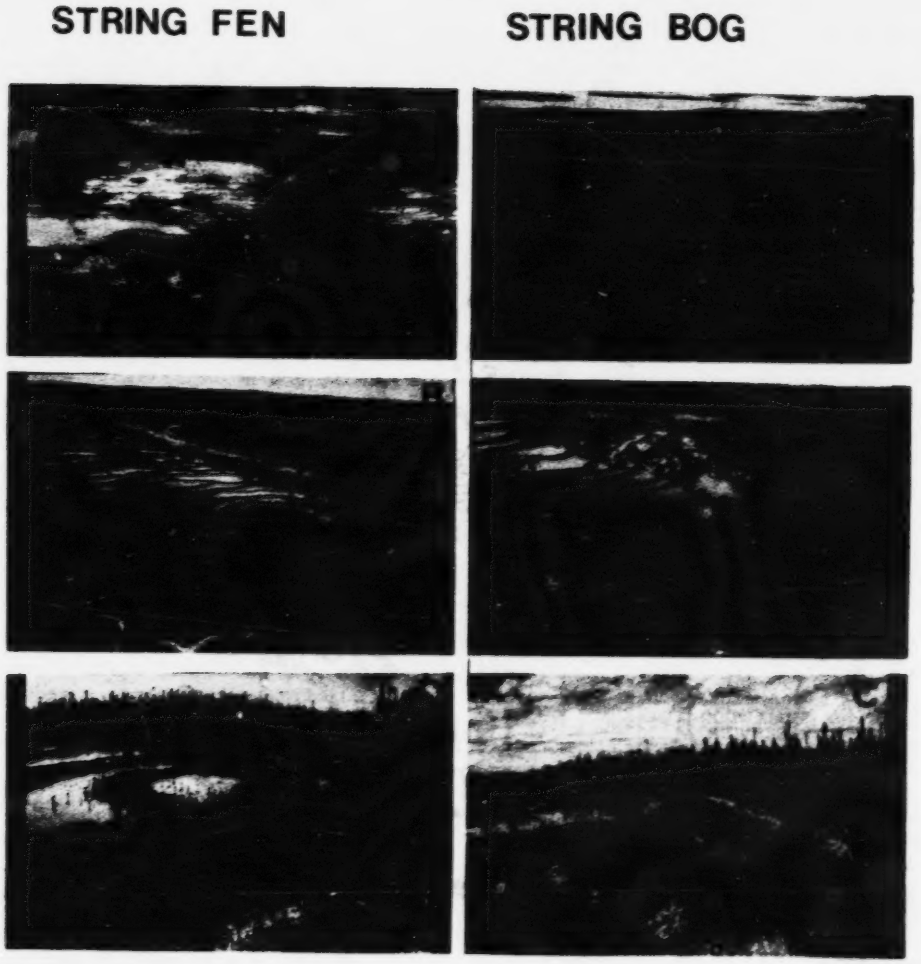

Figure 2: Oblique aerial photographs (A and B) and ground view (C) of string fen and string bog showing similarities in surface features. Approximate relative altitude: A: 500 metres, B: 50 metres.

One of the most important components of a peatland inventory is the recognition and identification of the different peatland types either from the air or from aerial photographs. Some peatlands can be identified by their topographic location or size, but the main identifying feature for many peatlands is the surface patterns when seen from the air. Since an inventory is usually undertaken to assess the potential of peat for fuel or peat moss, or to determine sites that could be utilized for agricultural or forestry purposes, a classification of peatlands is a useful data base and a helpful guide in conducting the inventory. This classification/inventory approach has been applied successfully in Newfoundland where the peatlands are selected, field-surveyed, and data-tabulated by morphological groups such as domed bogs, slope fens, etc. (see Pollett 1972, Pollett and Wells 1980, Wells 1981). Thus, the final data base consists of a group of morphological peatland types that have been ecologically classified, based on physical and chemical parameters, phytosociologically classified, based on floristic analysis, and inventoried by area and volume.

The classification and inventory of string bogs and string fens in Labrador appears somewhat problematic at this stage. Although the definition of bogs and fens (Tarnocai 1981) is essentially the same as elsewhere in Canada, the identification of patterned peatland types is often impossible especially from the air. Neither development nor distribution of either peatland type appears to be related to land type or geological substrate. In both eastern and western Labrador, the peat-covered terrain consists mainly of ablation tills or outwash sands and gravels. Overall, the distribution of fens is related more to higher altitudes and steeper slopes whereas extensive areas of bogs occur on the poorly draining plateaus of lower elevations. Yet, both string bogs and string fens often occur adjacent to one another in either of the regions.

In many instances the separation of string bog and string fen is only possible after analysis of the flora and/or the peat stratigraphy. But even this approach usually requires a sound knowledge of peatland ecology and the many parameters that differentiate bogs from fens. For example, the string vegetation in many of the peatland sites consists primarily of ombrotrophic bog indicator species such as Sphagnum fuscum, Rubus chamaemorus, Polytrichum strictum, Cladonia rangiferina, C. arbuscula, C. alpestris and C. mitis. Since these ombrotrophic sites may comprise about three-quarters of the surface vegetation, a classification of the site as bog would seem quite natural. Yet, the pools and wet flats of the site are often characterized by weakly minerotrophic indicator species such as Carex limosa, Menyanthes trifoliata, Drepanocladus revolvens, Calliergon stramineum, Betula michauxii, Smilacina trifolia, Equisetum fluviatile and Scorpidium scorpoides.

Thus, a classification of the site as fen would also seem quite natural since minerotrophy is one of the main parameters used to separate fen from bog. Allington (1961) also recognized this problem in western Labrador. She described the patterned peatlands as string bogs but indicated that "...most European authors would classify some of the areas as fen not as bog". Ground truthing, however, is a very time-consuming and costly component of any peatland classification or inventory. Therefore, the need for a more cost-efficient approach to peatland interpretation and identification must be considered.

Future work on peatlands in Labrador must include ecological studies in an attempt to understand their formation and development as well as establishing a classification of peatland types. The only aerial photo coverage of Labrador is conventional black and white (1:50,000; 1:20,000), which has limited capabilities for separating string bogs from string fens, and the more recent Landsat imagery. The latter remote sensing techniques have successfully been applied to peatland interpretation in the Hudson Bay Lowlands (see Boissonneau *et al.* this publication). Thus, development and testing of similar remote sensing techniques for peatland interpretation in Labrador must be completed before successful classifications and inventories can be initiated in that region.

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